1992

The Potential Loss of Coastal Open Space Due to the Utilization of Privately Owned Wastewater Treatment Facilities: A Case Study in Gloucester, Massachusetts

Eric W. Hutchins
University of Rhode Island

THE POTENTIAL LOSS OF COASTAL OPEN SPACE DUE TO THE UTILIZATION OF PRIVATELY OWNED WASTEWATER TREATMENT FACILITIES: A CASE STUDY IN GLOUCESTER, MASSACHUSETTS

BY

ERIC W. HUTCHINS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

IN

MARINE AFFAIRS

UNIVERSITY OF RHODE ISLAND

1992

MASTER OF ARTS THESIS

OF

ERIC W. HUTCHINS

APPROVED:

Thesis Committee

Major Professor ______________________

____

____

____

DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND

1992

ABSTRACT

The impact of privately owned sewage treatment plants, a viable alternative to on-site septic systems, is examined in regards to future land-use patterns. It was hypothesized that the use of these facilities would lead to a greater loss of open space, in the coastal City of Gloucester, Massachusetts, than if only conventional on-site septic systems were to be permitted.

Constraints to development such as zoning, wetlands, soil characteristics, parcel size, and economic viability were applied to undeveloped property in Gloucester. The results were used to indentify individual parcels and calculate the respective developability based on the two different scenarios. Only six individual parcels in Gloucester were found to possess the conditions needed to viably construct a development supported with a privatley owned sewage treatment plant. Thus, it was determined that constraints are too great in Gloucester to allow for a widespread use of these facilties. Supporting the hypothesis, on the six identified parcels an average increase of just under 300% developability was found to be possible.

ACKNOWLEDGEMENTS

I would like to thank my adviser, Dr. Bruce Marti, for all his help and guidance in completing this project. His academic standards are demanding and frustrating, but I know now that I have gained from them all. I would also like to thank the members of my committee, Drs. John Kupa and Gerald Krausse for all their help.

This thesis could have never been completed as proposed without the help and information that I received from the Community Planning Department of Gloucester. I hope they can at least find some enjoyment in looking over this thesis, and possibly a fresh idea to approach in regards to the future development of this City.

Most importantly I cannot thank all my friends and family enough for all their ceaseless support during my many times of need. They were always there when I needed them.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE PAGE

LIST OF TABLES

CHAPTER I

INTRODUCTION

Statement of the Problem

Increasing proposals by residential developers to utilize privately owned wastewater treatment facilities (POWTFs) threatens to significantly reduce the amount of undeveloped land in coastal areas of Massachusetts. These facilities manifest a technological solution allowing for the development of ecologically sensitive coastal areas where prior development was prohibited under existing environmental regulations governing conventional on-site septic systems. This study investigates the possible effects of this technology on the coastal open space in Gloucester, Massachusettts.

Hypotheses

Where municipal sewers are nonexistent, Title V of the Massachusetts State Environmental Code (310 CMR 15.00) provides explicit regulations for residential development regarding sewage treatment systems. Title V restrictions have been implemented to ensure a minimum standard for rural sewage treatment. Local boards of health are empowered to promulgate "reasonable" health regulations, which are stricter than the state minimums (310 CMR 11.02). Either way, new housing units are limited to only those parcels of land whose soils qualify for individual on-site disposal. To qualify, the soils must at least provide adequate percolation, allowing for a minimum flow of effluent through the soil.

The City of Gloucester has extensive tracts of land which do not pass the percolation criteria (Nakishima, 1988). High water tables, rock outcrops, and impervious soils have constrained residential development of these properties. Each of these characteristics acts to prohibit the use of individual on-site sewage disposal systems and has helped to retain a rural character throughout much of Gloucester.

The use of POWTFs may threaten the rural character of Gloucester. These facilities allow for residential development in areas which otherwise would fail to meet percolation tests (MAHB, 1987). Privately owned wastewater treatment facilities are essentially small modular treatment plants. They emit an effluent which is far superior in water quality standards than the comparable on-site septic system (USHUD, 1985). Significant reductions in biological oxygen demand (BOD) and nitrogen and phosphorous levels exist where POWTFs are currently in use (Quintel, 1988). The increase in the quality of the effluent discharge requires a much smaller total area for leaching the effluent into the ground. Many individual residential units could be located on parcels of land not suited for septic systems by tying them into a treatment plant which has access to an area of suitable soils.

Presently, POWTFs have only been permitted for commercial, institutional and condominium complexes. Legal implications, involving financial and operational liability of the owner, have prevented them from servicing a number of individual homes (MDEQE, 1988a). This study, however, assumes that these facilities will be permissible for residential subdivisions. Based on this assumption, it is hypothesized that the use of privately owned sewage treatment plants will lead to a greater loss of coastal open space, in the coastal City of Gloucester, than if only conventional on-site septic systems were to be permitted.

Justification for and Significance of the Study

The major rationale for conducting this research is to increase knowledge concerning the implications of the use of privately owned sewage treatment facilities within the coastal zone. Until recently, almost all research on these facilities has concentrated on their operation and maintenance and has been conducted by the United States Environmental Protection Agency (EPA). The only other studies concerning this technology and its land-use implications were conducted in non-coastal communities (MAPC, 1988a, and Clark Engineering, 1989). Significantly different results may be obtained by a coastal community study due to localized conditions such as wetlands, water table, soils, and zoning requirements.

Residential development pressure was high throughout Massachusetts during the 1980s. A flourishing economy and increased profitability to developers created tremendous incentives to develop almost any parcel of land (Quateman, 1987). A significant proportion of this development has taken place within the coastal zone. For example, the four communities with the highest estimated loss of open space acreage were all coastal communities (Massachusetts Audubon Society, 1987). Because much of the land which is suitable for housing in the coastal zone had already been developed utilizing either municipal sewering or septic systems, proposals for residential subdivisions have increasingly included the option of privately owned sewage treatment facilities (Shope, 1988). In Gloucester alone, two such proposals have been made which would circumvent the restrictions placed upon development by Title V. Even though neither of these developments were approved, the Massachusetts Department of Environmental Quality Engineering (DEQE), now the Department of Environmental Protection (DEP), did permit the use of over 80 existing and new facilities in 1987 and at one point were receiving two or three new proposals each week (Quateman, 1987).

Many of the proposals for the use of this alternative technology involve residential subdivisions, all of which have been put on hold, pending the completion and analysis of a state sponsored Generic Environmental Impact Report (GEIR). The need for the Report was spurred by a lack of understanding of the possible problems resulting from a widespread use of privately owned facilities. The Report's intended purpose was to examine issues such as: (1) technological, (2) legal and institutional, and (3) land-use implications (Kline, 1988). Goals of the Report were broad and not meant to be site specific. The GEIR was originally expected to be completed by the fall of 1988. Due to the State's recent financial crisis, the draft version was not made public until May of 1990 (ICF Inc., 1990). Further analysis of the GEIR will be made in the body of this Thesis.

In addition to the state GEIR, two bills were submitted in both 1987 and 1988 regarding the application and regulation of small sewage treatment plant technology (Massachusetts Legislature, 1987a, and 1988a). Although they did not pass, these bills proposed temporary moratoriums on the permitting process until the GEIR could be completed. Hearings by the DEP, the Executive Office of Environmental Affairs (EOEA), and many non-profit organizations unanimously supported these bills. Only the Homebuilders of Massachusetts are on record with an "unfavorable report" about the bills (Massachusetts

Legislature, 1988b).

The crux of the problem is that many communities have zoned residential areas assuming that they would never pass Title V requirements; therefore, they would never be extensively developed (Rupe, 1988). This assumption is supported by the premise that extending municipal sewers was often cost-prohibitive in rural areas, and no consideration was given to the construction of small treatment facilities far away from municipally operated sewers. Though Title V regulations were written essentially for public health reasons, many communities have apparently relied on them to limit development.

Even after repeated problems of unexpected development resulting from relying on Title V requirements to restrict growth, few municipalities have developed Master Plans which considered technological solutions such as privately owned sewage treatment facilities (Rupe, 1988). Many coastal towns experiencing expanded growth are only now attempting to update their comprehensive zoning plans in the face of approved and pending proposals that utilize this new technology (Britcha, 1988).

Statewide support for preserving open space in Massachusetts has recently been overwhelming. In November 1987, the Governor signed a five hundred million dollar open space acquisition bill (MGL C. 564, 1987). Within this acquisition fund, forty million dollars were specifically earmarked to purchase open space on coastal frontages. In addition, many other programs, to be supported by this fund, could lead to further protection of coastal uplands.

Even though the acquisition fund will lead to the preservation of some coastal lands, it may have little overall effect on slowing down development attributable to the use of privately owned sewage treatment plants. Because of a widespread support for preserving open space, it is important to expose the land-use problems that could be caused by the application of this technology before it leads to overdevelopment and the subsequent loss of coastal open space. Estimates of potential increases in development that this study reveals are required in order to focus future research on their possible secondary effects. These impacts could include loss of important wildlife habitat, increased non-point source pollution, and even a reduction in the "quality of life" within the surrounding community.

Methodology and Procedures

Using both a quantitative and qualitative case study approach, this study describes and evaluates the land-use implications resulting from the utilization of privately owned sewage treatment plants. The combination of these two analytical designs can result in increased validity and reliability of a study (Kidder and Fine, 1987). A qualifying factor for each research design is that a "bounded system" must be identified as the focus of the investigation (Smith, 1978). Within this study, the "bounded system" will be limited to the geographical boundaries of the City of Gloucester, Massachusetts. By using the case study approach, it becomes possible to concentrate on many, if not all, the variables relating to a single phenomena (Merrian, 1988).

Gloucester, a coastal city encompassing a total of 26.6 square miles, is bounded by 64 miles of tidal shoreline (Gloucester Conservation Commission, 1984). The study area has physical features representative of the State's coastline as well as inland areas. Features, all of which can influence the adjacent area's development potential, include rocky shorelines, barrier beaches, inland waterways and extensive wetlands.

To test the major hypothesis, this thesis determines the development potential and the subsequent loss of open space throughout the City which could result if privately owned sewage treatment facilities were fully utilized. The results are used to test the major hypothesis which forecasts that this innovative technology, if permitted, can lead to a greater loss of coastal open space than under existing environmental regulations governing septic systems. The objectives of the research are to compare this value with the loss of open space which could similarly result by using conventional on-site septic systems on the same parcels of land.

This research follows a comprehensive sampling procedure defined by Goetz and Le Compte (1984). Therefore, it attempts to identify and examine every potential instance where the technology could be used within the study area. The methodology used for this study is based on a combination of the methodologies used by two previous build-out scenarios which similarly evaluated the land-use impacts of privately owned sewerage treatment facilities. In order to determine the potential loss of open space between the two scenarios, the following sequence of procedures are performed:

1) Determine the minimum size of a POWTF which could be used. Size of the facility is a function of the cost -effectiveness of those who tie into the facility.

2) Calculate the minimum sized parcel for inclusion within the study, based on the size of the treatment plant and correlated to the least restrictive zoning category within the city. For example, if a determination is made that a facility would only be cost-effective by serving a minimum of 40 housing units, then in an area of zoned as one house per acre, a minimum of 40 acres would be required. An additional 20 percent of the acreage is assumed to be necessary for roads and utilities, along with one acre for the treatment plant and the adjacent leaching field.

3) Identify all individually owned vacant parcels greater than the minimum size requirement, excluding public

open space. It is assumed that residential developers will not buy two adjacent parcels in order to meet the minimum size requirement.

4) Exclude all parcels located within the boundaries of the municipal sewerage district. These parcels could presumably be developed without a privately owned treatment facility.

5) Inventory each vacant parcel by zoning district, and exclude those parcels which cannot support the minimum number of housing units. Zoning changes are usually permitted for less destructive uses, thus established business and industrial districts could utilize the residential zoning criteria of adjacent parcels.

6) Inventory specific acreages of environmental constraints such as wetlands, and open water bodies. Areas possessing these constraints, including their appropriate buffer zones, are subtracted from each parcel since they are prohibited from development by the Massachusetts Wetlands Protection Act.

7) Determine the extent and location of suitable soils which can be used for either a septic system or treatment facility leaching field among the remaining

parcels of vacant property. This step incorporates local and state regulations, site specific data as well as the potential use of site mitigative procedures which could allow development.

8) Produce a final determination of developable land based on whether or not an on-site septic system or treatment plant is used. This identifies the consequent potential loss of coastal open space.

Synopsis of Chapters

Each chapter of this thesis presents a different aspect of the circumstances pertaining to the use of POWTFs and their possible land-use impacts. Chapters II and III both focus on the issues involving land-use and open space and set the stage for evaluating the impacts of development which utilize POWTFs. Chapter II also introduces the theoretical and functional meaning of land-use and open space. The emphasis is to show that land values vary with different perspectives and that in particular open space land has many different values depending on the point of view. Chapter III is an extensive look at the development picture in Massachusetts, focusing on the development boom of the 1980s. It also includes an extensive look at the land preservation efforts throughout the State.

Chapter IV presents the regulatory and technical aspects of wastewater treatment in rural areas. The focus is on traditional septic systems and POWTFs. For both the function, application, limitations and how regulations affect their potential use are explained.

Chapters V and VI together focus on the experimental aspects of this thesis. Chapter V provides a profile of the study area, the Town of Gloucester, Massachusetts. In addition to physical parameters, Chapter V presents a historical and contemporary view of Gloucester land-use and the forces which have created the present scenario of development. Chapter VI essentially takes the land-use issue one step further by projecting potential land-use patterns based on the application of traditional septic versus POWTF technologies compared for rural wastewater treatment. Discussion based on these results focuses on the political, environmental and regulatory implications of land-use impacts that may result from the use of POWTFs.

Conclusions, policy implications and future research ideas are included in the final chapter.

CHAPTER II

LAND-USE AND OPEN SPACE

The use of land is a complex activity which is influenced by physical, economic, social, and legal factors. These factors, in combination and also acting independently, determine the eventual use of a particular parcel of property. Because there are so many different influences, most land-use decisions usually involve more than one interest group. Each interest group defines and defends alternative land-uses, which are often mutually exclusive of each other. However, no matter how difficult it is to interpret or develop land-use policies, choices are made as to the future use of land.

Deciding what use a particular parcel will be used for is often a difficult, time consuming, and potentially expensive process. Historically, economics have played an important role in the final land-use choice, thus it has been a major influence in competition between potential land users (Mather, 1986). What has often resulted is that the chosen land-use was the one which would lead to the highest possible economic rent, whether that be agricultural, industrial, residential, or recreational. Location and surroundings will usually determine what land-use will have the highest value. Nationwide, this decision-making process has led to vast tracts of land being designated for particular uses which may not have taken into account non-economic characteristics, such as open space preservation.

Even though economic incentives for land-use decisions still exist, land-use planners and commissions are increasingly incorporating non-economic valuations of open space, when deciding the appropriate uses for land. Complicating the situation is that in many cases properties were already zoned for a general category long before the value or need for open space was ever weighted into the decision process. This leaves governmental permitting agencies, at all levels, trying to cope with the problem of allowing a development which conforms to a predetermined land use category, while the constituency for open space preservation continually grows.

The Concept of Open Space

Definition of Open Space

The concept of "open space" may be one of the most ambiguous terms that exists in the field of regional and community planning. This is not because there have not been attempts to define and use the term. Instead, the dilemma lies in the fact that it is very subjective in meaning and has a wide range of uses. A conservationist for example, may interpret open space to refer to land which is pristine or void of all man-made disturbance. A developer, however, could define open space as meaning parking lots, playgrounds, and sidewalks found within the confines of a residential subdivision (Platt, 1972). Clearly, the definition of open space is dependent on the desires of the parties involved. Within the context of this thesis, open space is defined as any land which has not been developed.

Depending on the circumstances and individuals involved, open space can be considered either a positive or negative attribute to a community or an individual development. For example, an exclusive suburban community often defends the preservation of open space in order to preserve aesthetics, privacy and the community image (Caputo, 1979). In defense of this interpretation, open space is used as an environmental cliche, which has been described as "...the natural prey of that scourge, 'urban sprawl'" (Platt, 1972, p.1). Conversely, officials of a less fortunate community may view open space as a waste of potential tax revenues (Platt, 1972). In line with this view, open space would be reserved only for that land which remains undeveloped due to physical constraints such as wetlands, steep slopes or poor soils.

Open space preservation is often equated with saving for the future and keeping it from harm, decay, or loss, which could result from development (Mather, 1986). Because of this attitude and regardless of individual interpretations, the one clear trend in the past few decades has been toward the preservation of open space of all types of land. With many recent pieces of major environmental legislation since the mid 1960s, there also exists some form of reference to the preservation of open space. Even though conservation movements have historically risen and fallen with each passing year, environmental legislation that included the topic of open space, is seldom ever repealed (Mather,1986).

The Justifications for Preserving Open Space

The justifications for preserving open space not only vary from one location to another, but with each individual site. They are based on the principle that different segments of society place different values on an otherwise identical parcels of land (Platt, 1972). One segment's reasoning may be to protect a threatened species or unique habitat, while others may be concerned with property devaluation due to excessive urban sprawl. Even though the reasons may be based on entirely different premises, the desired outcome is to prevent the alteration of the existing integrity of a property. With the common goal of preventing unwanted development, different constituencies combine their strengths in an attempt to more effectively promote their cause.

The greatest problem for land-use decision-makers is agreeing on a basic value of preserved open space (Mather, 1986). With any land-use decision there usually are two opposing views in regards to the eventual use of a property; one representing a preservationist viewpoint, the other for development. Therefore, some sort of value system is needed in order to compare the advantages and disadvantages between the different view points. In order to more easily explain the justifications for, and value of, open space, it can be divided into three categories; social, environmental, and economic. While each can be differentiated, there are often overlapping values. For example, both the social and environmental value of open space preservation can contribute economic benefits, while conversely, economic value can contribute social benefits. Overall, these different value perspectives of open space depend upon the particular property under investigation and often incorporate much subjectiveness by those conducting the evaluation.

More specific factors must be considered when trying to consider the social, environmental, and economic values of open space preservation. One factor is whether or not a property is under public or private ownership. Privately owned open space may offer little or no physical public access or use if trespassing is forbidden. However, even privatization reserves many external values for the public such as intrinsic, wildlife sanctuary and watershed protection. Each value, whether or not the property were to be available to the public, needs to be evaluated further in terms of the future use of the site. In some cases, there is justification for preserving open space with the option of future development. By preserving open space, there are always the possibilities that the land could be developed in some way in the future. Ultimately, the preservation or development of property is based on society's own purposes; and subsequently, some areas of open space are justified while others are not (Willis, 1985).

Social

The social value is considered the most important reason to preserve open space (Willis, 1985). The social value is predominantly comprised of community image, amenities, and recreation. What the above options all have in common is that they are primarily based on society's perception of its surroundings and "quality of life". However, because perception is hard to quantify, it becomes difficult to apply it to land-use decisions. Nevertheless, a consensus does exist on the significance of social value in land-use decision-making (USEPA, 1973).

Open Space can be utilized for maintaining or shaping a community's image (Caputo, 1979). By intermingling open space with development, which adds diversity of natural elements, the feeling of crowding can be avoided. It can act as a screen to unsightly development and break up the visual monotony of urban sprawl. Areas such as parks and greenbelt are used to create favorable attitudes in providing for a human need while simultaneously serving a basic reassurance and protection function (McCarthy, 1989). Besides any material importance, land has value as an amenity. Many people regard open space and scenic views as valuable and worth protection for their own sake, without any connection to economic principles. Even under optimum conditions, how can an appropriate economic value be placed on a beautiful sunset? The reason it is often referred to as "priceless" is because it cannot adequately be expressed in dollars and cents. One important aspect of the aesthetic value of open space is that, in many cases, the property itself does not even need to be encroached. Part of the appreciation of open space is hypothesized to derive from "...a purely emotional or psychological attachment which stems from man's biological dependence on land..." (Mather, 1986, p.14). Many people who do not even own property have a strong interest in the uses of the land around them. This allows those persons to enjoy the aesthetic characteristics of privately owned open space without physical trespass.

Recreational use is probably the most apparent and common social value of open space. Practically everyone, many on a regular basis, utilize the recreational opportunities furnished by open space. Parks, beaches, state forests, and protected wetlands represent just a few of the areas where people go to relax, swim, hunt, or just observe the natural environment. The demand for open space recreational activities continues to grow nationwide and many areas are reaching reaching their capacities during the peak season.

Environmental

By preserving the environmental integrity of open space there are both visually apparent as well as more concealed benefits to society. These benefits include the protection of plant and wildlife diversity, continued operation of valuable natural functions, and aversion from the dangers of development in sensitive areas. These benefits are often cited by preservationists whenever development of land is proposed.

Unaltered habitat is increasingly being recognized as an important criteria for preserving species diversity. Development leads to habitat fragmentation which can leave only small patches of unadulterated land, leaving extensive edges between the two (Leahy, 1988). Habitat edges lead to increases in those species which are considered detrimental to other species and are already overpopulated, including, i.e., cowbirds, jays, oppossums, and raccoons. Additionally, the total quantity of potential wildlife and plant habitat for all species is reduced by extensive development. By preventing habitat fragmentation, species diversity can be protected permitting for a healthy natural system which can be utilized for both observation or harvesting.

Open space can play an important environmental role by functioning as watershed area, a water purifier and a flood control device (Caputo,1979). By utilizing the natural processes of open space, communities can, in some cases, reduce or avoid the need for costly wastewater treatment and filtering technology (Sherwood, 1988). Open space plays a role in flood control by absorbing and reducing the quantity of overland flow. Sidewalks, houses, streets and even lawns have relatively little absorption capabilities compared to undeveloped natural open space (Schueler, 1987).

An additional environmental justification for preserving open space is to prevent development in areas susceptible to natural hazards, especially those prone to periodic flooding. Historically, development has occurred on barrier islands, river floodplains, and generally in low lying areas. These areas have been chosen for development because of their proximity to waterborne transportation, fertile soils resulting from periodic flooding, and flat terrain preferred for construction. As described by McHarg (1978, p. 1) many Americans feel that they have "the intrinsic right to drown his wife and children, otherwise he (man) would not build in flood plains". His opinion clearly states that areas prone to hazards should be left alone from development. Though laws do exist which restrict development in some flood prone areas, they are not adequate to protect from all natural phenomena. Overall, the environmental justification for preserving adequate open space is to retain a healthy working ecosystem, one which serves society instead of exhausting it.

Economic

There are different economic reasons for preserving open space. Most quantitative economic research has focused on the hypothesis that property adjacent to open space is significantly more valuable (Evans, 1973; Hall, 1973; Hammer, 1974; and Little, 1979). These hypotheses have been substantiated through regression analysis which has shown a positive correlation between the value of property and the distance from open space (Correl, et al ,1978). This correlation, however is not adequate enough to conclude that all open space should remain undeveloped. What is more important in economic terms are the opportunity costs that result when a property is not developed.

Determining the efficient amount of open space in regards to its opportunity cost is a difficult process. However, a major conclusion, by Evans (1973); and Hall (1973), is that the benefits should greatly exceed the value of open space before a change is allowed because of the uncertainty and irreversibility of a land-use change.

Whether or not monetary value is determined for preserving open space, their are irrefutable economic incentives for doing so. For example, while open space may not be materially used, it is valued for aesthetic reasons.

It is argued that tourism and recreation values of open space are sometimes based on the resource of land in much the same way that agricultural value is based on soil (Mather, 1986) The amenities of open space, which include the opportunity for relaxation, outdoor sports, and nature observation, are activities that people are willing to pay for (Caputo, 1979). Furthermore, the result of not preserving open space and allowing "sprawl" is considered the most expensive form of residential development in terms of economic costs, natural resource costs, environmental costs, as well as, many types of personal costs (USEPA, 1974).

The Relationship between Open Space and the Coastal Zone

Coastal open space has many characteristics which attract commercial, residential, and recreational development. However, coastal development vies with unique ecological habitats for fish and wildlife, scenic areas, and other benefits for the general public. There is mounting support that too much growth in coastal areas can exceed the outward limit to which this environment can sustain. Consequently, there is an increasing concern over the environmental and aesthetic effects from coastal development.

There are many different definitions of the geographic boundaries of the coastal zone. Guidelines by the Coastal Zone Management Act (CZMA) (United States Congress, 1972) do not clearly indicate how the inland boundaries should be determined. In Section 304-a, it only states that the whole coastal zone is made up of shorelands and coastal waters which are "strongly influenced by each other" and shorelands are to be included if they can cause "direct and significant impacts on the coastal waters". The inland delimitation was left up to the individual states; subsequently it is extremely varied from one state to another.

The volume of literature on the characteristics and value of coastal open space has been expanding since the CZMA was passed in 1972. Much of the research has focused on the importance of aesthetic and visual qualities of the coastal zone (Ulrich, 1981; Blomberg, 1982; Smardon, 1982; and Wohlwill, 1982). It has been shown that the presence of water in any form brings to mind a positive response on the part of the average person (Ulrich, 1981). These perceptions then can lead to the problem of development which may not be "congruent" in its relationship with its surrounding natural environment and thus can be evaluated negatively (Wohlwill, 1982).

A methodology, which performed an examination of the key thoughts and perceptions in literature involving the coastal zone, has been used to identify some of the qualities that have inspired authors to write (Blomberg, 1982). This approach was used to reveal some of those attributes which should be closely studied by coastal managers. It was discovered within the literature that many of the reemerging thoughts focus on the perception of open space and the sense of distance when referring to the coastal zone. The perception of open space found in this literature search referred to not just the shoreline, but also to coastal upland areas. One of the major attractions to the coast, as summarized by Bloomberg (1982), was that the coast is perceived as wilderness land even under conditions existing today.

> "Even though the ocean and its shores are touched and affected by man, it covers and removes these intrusions quite effectively, and retains at least an image of its primal, untrammeled state." (Bloomberg, 1982, p. 69)

The theme found throughout literature about the sense of openness and wilderness leads a prospective developer to pay a premium for proximity to beaches, water views, and frontages on the ocean. Part of the attraction to the coast often cited by people is just the ocean smell. Empirical data has shown a positive correlation between a decrease in distance from the shoreline and an increase in the value of property (Brown, 1977). Brown's (1977) reason for studying shoreline values was to determine the amount of open space around a water body which was optimal in an quantitative sense. However, by assuming that coastal open space is a public good, the optimal amount of open space was found not to cover the costs to an entrepreneur. Thus, there is little economic sense for a developer to retain any excessive quantity of coastal open space which can be utilized by the general public.

The current literature supports the growing recognition that coastal open space is important and that proper management and use is crucial. There has been legislative response, though not always direct, at the federal, state and municipal levels to protect and manage the qualities of coastal open space. For example, included in the statement of the purpose of the CZMA (1972) was to...

> "...encourage states to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historical, and aesthetic values...".

Many states, with federal guidelines in mind, have included aesthetics into their coastal plans. Aesthetics are considered in the coastal zone management plans of Connecticutt, Delaware, Maryland, Michigan, Mississippi, New Hampshire, New York, North Carolina, Virginia, Texas and Massachusetts. Aesthetics used in this context would unquestionably include open space within the realm of its definition.

CHAPTER III

LAND-USE AND CONSERVATION IN MASSACHUSETTS

Statewide Development

Beginning in the early 1980s and continuing through early 1989, the rate of residential and commercial development throughout Massachusetts had been enormous. There are two generally accepted theories for this phenomena with development proceeding because of both: 1)instate relocation; and 2)interstate migration. In reference to why more people were choosing to move to and build homes in Massachusetts, it was noted by the state's lead environmental agency that "...all things beings equal, recreational opportunities may be the differential needed to make a choice.." (MEOEA, 1985, p.4). In particular, much of this development has been attributed to the extensive coastal amenities which act as an attraction to the high technology skilled labor force (Business Week, 1985). Coastal recreational opportunities found along the shore such as boating, beaches, and fishing play a leading role in that attraction. In addition, new development has also been linked to a redistribution of the state's population and businesses from traditional urban centers to suburban and rural communities (Yaro, 1989).

Development proposals accelerated in all regions including many controversial "swamp-busting" projects such as the Attleboro shopping mall, which, had it not been denied by the Environmental Protection Agency, would have filled more than 30 acres of Sweedens Swamp in Massachusetts. In this case, the permit denial was the first of its type in New England, based on the guidelines under Section 404(b)(1) of the Clean Water Act. Only because a viable alternative site existed, when the environment was to adversely affected, was the permit denied. Had an alternative site not been available, the shopping mall potentially could have been permitted. Even though Massachusetts is considered to have some of the strongest wetland regulations in the country, its wetlands, in addition to other less regulated properties, are still under attack. This threat is vividly described within a newspaper series focusing on statewide wetlands loss.

> "From the Berkshires to the Boston suburbs, the bulldozers are on the move in cattail marshes and red maple swamps, evicting muskrats and displacing red-winged blackbirds" (Dumonoski, 1989, p.1).

While wetlands only constitute a small but important part of developed open space, it has been estimated that for every acre of wetland threatened, five acres of farmland, and ten acres of forested land are also in danger of development (Yaro, 1989). Because of recent concern over burgeoning development, both state and municipal agencies, as well as non-profit organizations, have been assessing the quantity and potential affects of the loss of open space. In particular, the Massachusetts Audubon Society has been educating the public about the environmental, social, and economic consequences resulting from excessive development throughout the State. In 1987, the Audubon Society published a report entitled Losing Ground: The Case for Land Conservation in Massachusetts (Greenbaum and O'Donnell, 1987). Then in 1988, it published a complementary report titled Eden's End: The Case for Ecological Protection In Massachusetts (Leahy, 1988). The first report is a compilation of data showing locations and specific rates of statewide development. The second report focuses on the ecological consequences of continuing development in terms of habitat loss, pollution, and increasing numbers of threatened and endangered species. Combined, the two reports are a significant effort by the Audubon Society to sway public opinion in order to slow the pace of land development in Massachusetts.

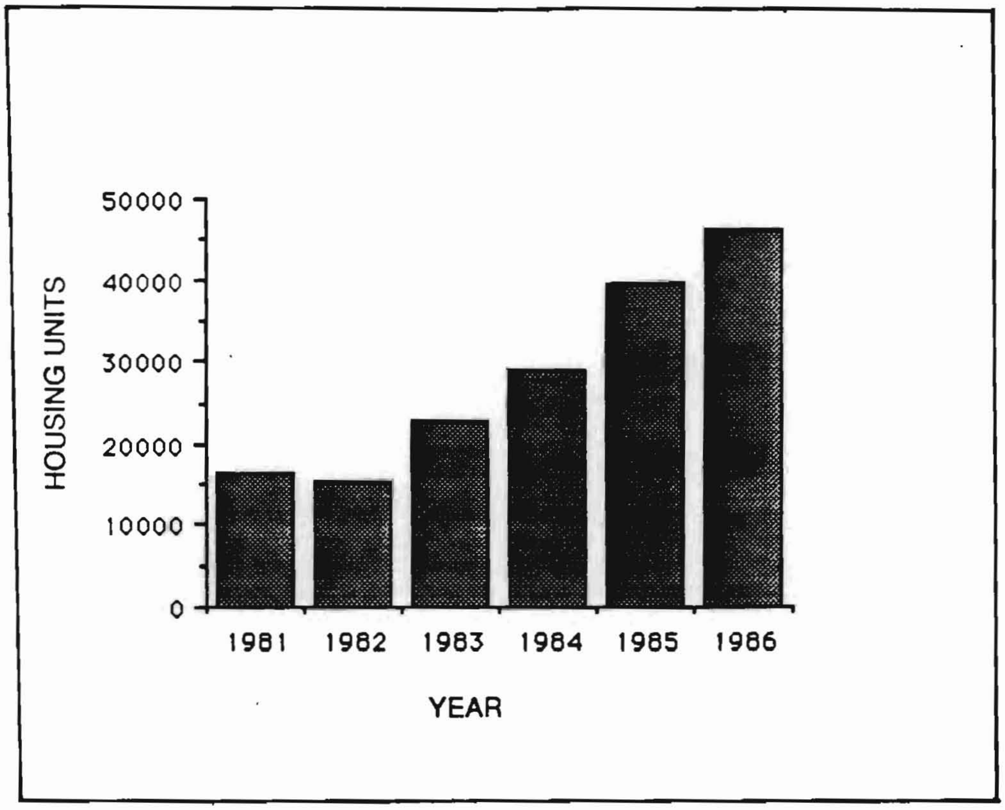
Written by representatives of a non-profit and obviously pro-environment group, the conclusions, recommendations, and projections contained in both of the Audubon reports must be considered at best subjective. However, the actual quantifiable data was predominantly cited from both federal and state environmental agencies and can be regarded as generally valid and sound.

The most vivid portrayal of the loss of open space throughout the State can be expressed in the number of acres of land which have been developed. From colonial times to 1970, the amount of land developed in Massachusetts had reached approximately 714,000 acres, representing 13.5 percent of the state land area. From 1970 through 1980 the annual consumed land growth rate of 2.27 percent led to an additional 180,000 acres of developed land (MacConnel, 1987). Only at a slightly slower rate (1.99%), approximately 112,000 acres had been developed by 1986 (Herr, 1987). The Audubon Society even went as far as to make projections of total land consumed by the year 2030 based on a slowly decreasing growth rate (See Table 1). Statewide, the rate of development peaked in 1986 when over 30,000 acres of open space were transformed in one year alone (Herr, 1987). A graphic comparison is that as of 1975, an area the size of Rhode Island had already been developed. However, at the rate of development in the 1980s, it would only take until about the year 2010 to develop the equivalent of another Rhode Island.

Another indicator which correlates to the total acres of developed property in Massachusetts is the total number of authorized housing units (See Figure 1). Other than in 1982, there were significant increases in authorized housing units with each passing year between 1983 and

FIGURE 1

NUMBER OF AUTHORIZED HOUSING UNITS IN MASSACHUSETTS 1981-1986



Source: Greenbaum and O'Donnell, 1987

TABLE 2

LAND-USE CHANGES WITHIN MAPC REGION

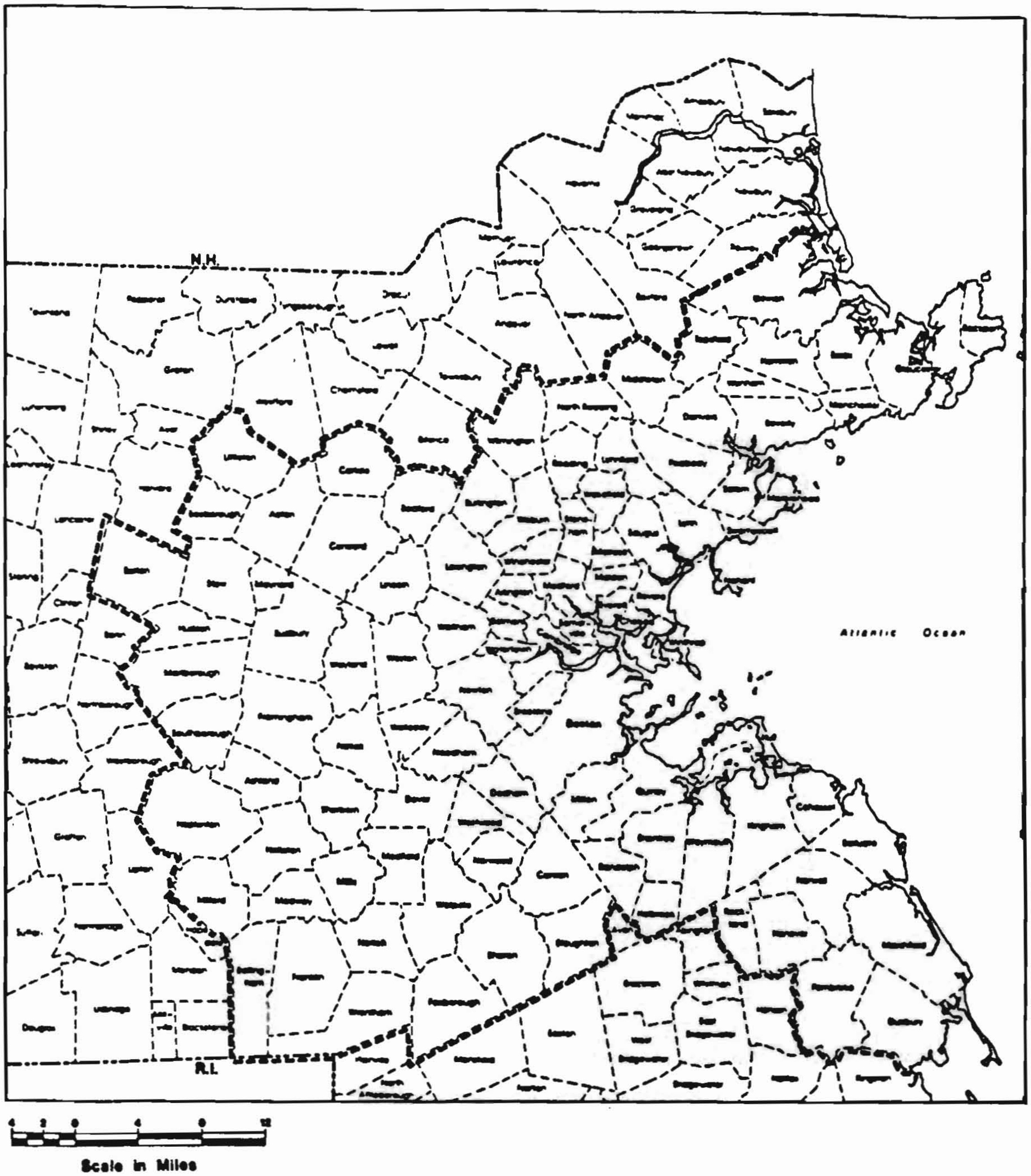
1971-1985

	1971 Acreage	1985 Acreage	% Change
URBAN			
Industrial	14,493	19,594	35.2
Commercial	19,223	22,401	15.5
Residential			
multi-family	10,144	13,178	29.9
dense	65,396	65,719	0.5
medium	100,926	108,447	7.5
light	74,669	90,040	20.6
Transportation	19,061	19,919	4.5
Open and Public	27,915	29,311	5.0
Total	331,827	368,609	11.1
AGRICULTURE (total)	51,371	46,565	-9.4
OPEN LANDS (total)	24,998	20,693	-8.3
FOREST (total)	398,541	371,206	-6.9
RECREATION (total)	20,713	21,301	2.8
WETLANDS (total)	84,213	83,377	-1.0
MINING (total)	7,436	6,630	-10.8
WASTE DISPOSAL (total)	2,013	2,234	11.0

Source: MAPC, December, 1988c.

FIGURE 2

METROPOLITAN AREA PLANNING COUNCIL LOCATION MAP



Source: Metropolitan Area Planning Council, 1992.

clearly intensified throughout the entire State. However, the demand for property along the shoreline, and within coastal municipalities in general, received an unproportionate share of development pressure. Demand for coastal property and amenities can be measured by both direct and indirect variables. These variables include increased recreational use, monitoring environmental parameters such as coastal pollution, and simply measuring the growth in development, gauged in terms of the number of houses and acres developed.

The coastal environment of Massachusetts has many characteristics which act to attract all segments of society. Qualities conducive to passive recreation include: unique habitat for birdwatching; open space simply for the experiencing of tranquility; and enjoying the cool ocean breeze. Likewise, fishing, swimming, and shell collecting are more active uses, which account for a large share of the attraction.

The demand for these coastal amenities in Massachusetts has been increasing. As a result of extensive coastal immigration and development, the demand for coastal recreation has exceeded the available supply (MDEM, 1980).
For example, it is common for beach parking lots to fill up only hours after opening. Because of this situation, municipal beaches often reserve much of their parking facilities for residents only. Even then, many residents

are denied parking due to lack of space.

Exacerbating the problem of increased beach demand is the location of many of the public beaches. End to end Massachusetts has approximately 940 miles of sandy beaches (MDEM, 1980). Ironically most of it is far from the majority of the State's population. While 75 percent of the public beaches lie to the south of Duxbury, 65 percent of the population lives to its north (Brautigam, 1985). However, even with the population center being up to two hours away by automobile, beaches in both the Boston area as well as the Outer Cape are being filled to capacity.

Coastal Development

Recreational demand in coastal areas will increasingly become more difficult to meet than other regions in the State because of the limited availability of undeveloped property. Historically most of the State's development has been in close proximity to the coast, and in the building boom of the 1980s; this trend continued even though proportionately there is much less available land than in many undeveloped inland regions.

Of the State's 311 incorporated municipalities, 78 are included within the Massachusetts Coastal Zone Management Program. Massachusetts' coastal zone generally includes all coastal areas between New Hampshire and Rhode Island, landward to 100 feet inland of specified major roads, railways and other visible right of ways. All of Cape Cod, Martha's Vineyard and Nantucket are also included. While only encompassing under 25 percent of the State's total area as of 1980, the communities within the coastal zone accommodated approximately 35 percent of the State's population (MDEM, 1980).

Between 1981 and 1986, the rate of both residential and commercial development in the coastal communities has been extensive. Of the 15 communities with the highest amount of land consumption, eight were located on the coast (Herr and Robinson, 1987)(See Table 3). During this time period, a total of 10,714 acres were developed in these eight communities alone, representing just over 10 percent of all statewide development. Although each of these communities are located within the Plymouth-Cape Cod-Islands region, coastal communities on the average underwent greater development compared to inland regions (Herr and Robinson, 1987). During the six year time period (1981-1986), an average of about 3.2 percent of all coastal community land was developed. Comparatively, an average of only about 1.6 percent of inland communities as a whole were developed (See Figure 3). Exacerbating this situation is that on average, coastal communities were already more heavily developed than inland ones where relatively more land is available.

Shellfish pollution as development indicator

One of the indirect consequences of expanding

TABLE 3

COMMUNITIES WITH HIGHEST ESTIMATED DEVELOPMENT

1981-1986

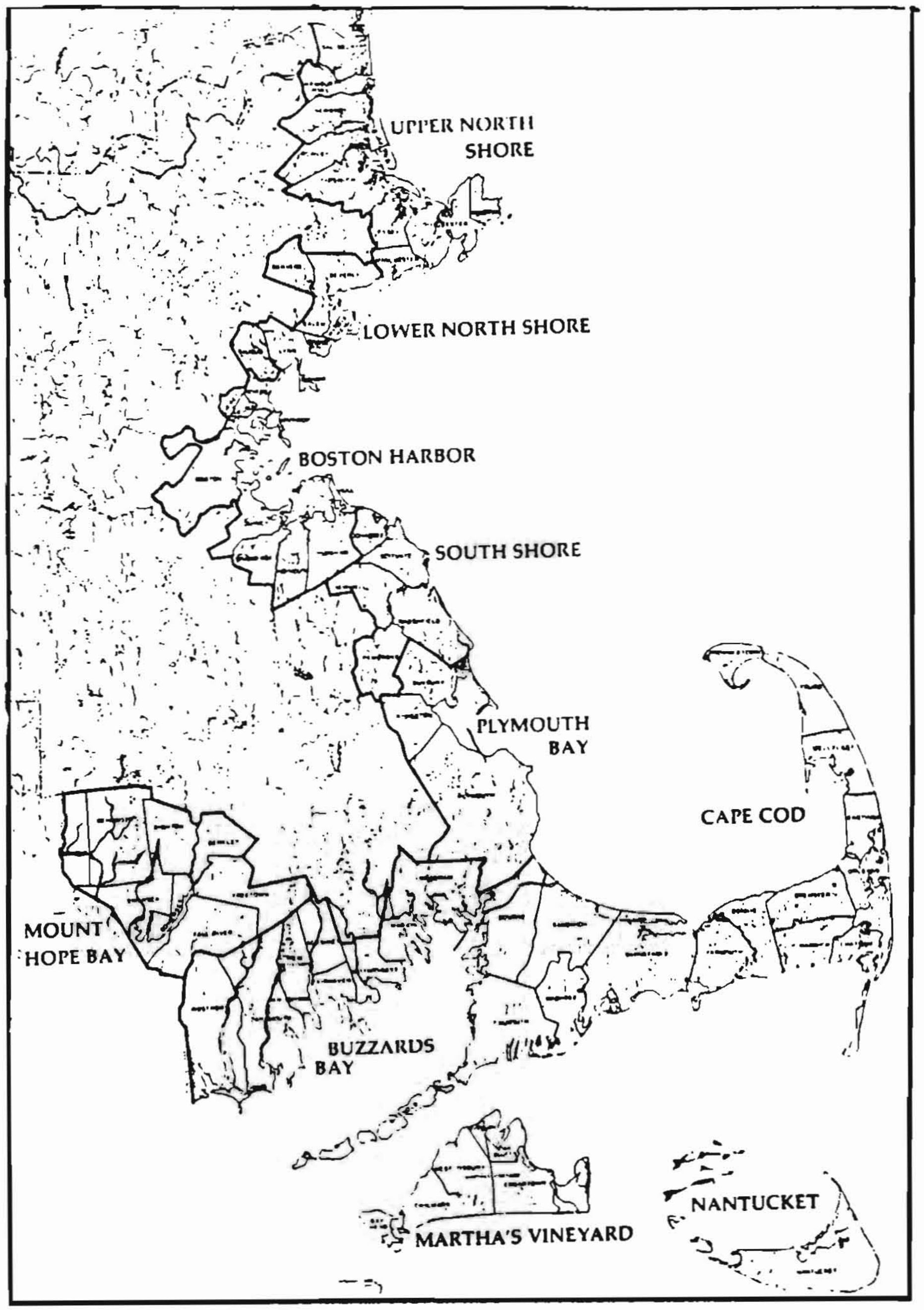
Rank	Municipality	Area	Acres Used
1	*Mashpee	Cape Cod	2,215
2	*Brewster	Cape Cod	1,829
3	*Barnstable	Cape Cod	1,548
4	*Sandwich	Cape Cod	1,426
5	Ashland	W. of Boston	1,306
6	Mansfield	S.W. of Boston	1,057
7	*Edgartown	Martha's Vineyard	1,038
8	Chelmsford	Merrimack Valley	958
9	*Falmouth	Cape Cod	951
10	Franklin	S.W. of Boston	940
11	Tewksbury	Merrimack Valley	919
12	*Nantucket	Nantucket	891
13	*Plymouth	Plymouth County	816
14	Tyngsborough	Merrimack County	811
15	Andover	Merrimack	804

* Coastal Communities

Source: Herr and Robinson. <u>Analysis of Land Consumption</u>. 1981- 1986.

FIGURE 3

MASSACHUSETTS COASTAL COMMUNITIES AND REGIONS



Source: Massachusetts Coastal Zone Management, 1991.

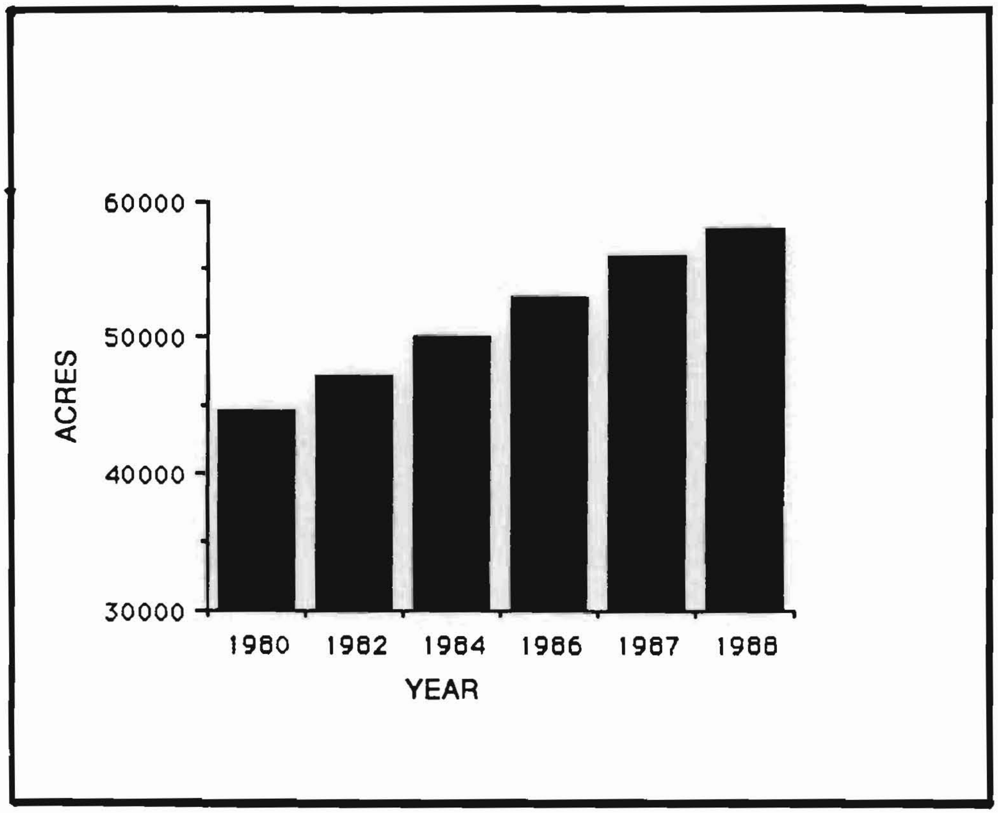
development in coastal areas is an increasing incidence of pollution of adjacent coastal waters. Research, using 27 years of data from the North Carolina Coast, which utilized regression analysis, has shown a positive correlation between the increase in residential development and the quantity of closed shellfish beds due to bacterial contaminating (Maiolo, 1981). Coastal development leads to shellfish bed closures because it increases the amount of pathogens and fecal coliform in surface water runoff and groundwater entering the ocean through point and non-point sources (Buzzards Bay Project, 1989). In Massachusetts, this problem has become critical. Statewide the total amount of closed shellfish beds due to bacterial contamination has been steadily increasing with each passing year (Buzzards Bay Project, 1988) (See Figure 4). These increased closures correlate directly with increased development over the same time period.

Massachusetts Restrictive Coastal Law

The diminishing availability of access to and use of the State's shoreline is apparent to all who frequent the coastal area. Increasingly, numbers of coastal property owners are exercising their property rights by posting "no trespassing" signs along the shoreline (Healy and Zinn, 1985). These assertions are based on Massachusetts coastal law, which is rather unique in that it acts to restrict public use within the intertidal area. Many unsuccessful

FIGURE 4

MASSACHUSETTS ARCES CLOSED TO SHELLFISHING
1980-1988



Source: Buzzards Bay Project, 1989.

attempts have been made to change these laws, while the problem itself intensifies because of continuing coastal development.

The Colonial Ordinances

The laws which govern intertidal lands in Massachusetts are an important factor when considering any use or protection of coastal property. These laws originated in 1641 to protect public rights of "fishing and fowling" in tidal waters and were incorporated into the Colony's Original Body of Liberties (Frankel, 1969). The Colonial Ordinances were amended in 1647, resulting in the extension of upland property rights to the low water mark or 1,650 feet, whichever was the shorter (Grabler, 1982). Ironically, while originally intended to preserve public rights along the coast, the amendments were intended to encourage upland property owners to build wharves, which at that time were vital to the economy of the colony. Even though the Colonial Ordinances privatized the intertidal zone, the public right of fishing and fowling still remained and the amendments included navigational needs (Mass. Laws and Liberties, 1648). The Supreme Judicial Court, in 1810, found the amendment to be necessary for commerce because the colony could not build wharves for commercial development at public expense (Storer v. Freeman, 1810).

The Court's narrow interpretation of the public trust in tidelands has hindered efforts to expand the already limited amount of public access to the shore. These rights have received extensive public support, but they are no more conducive to a public right of passage in the intertidal zone today than they were in 1647. Surprisingly, it appears they may actually be more restrictive. This fact is an opinion of the Justices, which in 1974 noted that private development could legally prevent all public passage, other than navigation, in the intertidal zone (Opinion of Justices, 1974). This interpretation not only refers to commercial waterfront businesses, but also to residential development. Ultimately, the only complete right preserved in the public trust doctrine, as conceived in Massachusetts, is navigation.

The effect today of the Colonial Ordinance and Amendments is to severely restrict all public use except for "fishing, fowling and navigation" within the intertidal zone. This means that an unlimited number of persons with fishing rods could legally crowd a beach, but a couple attempting to enjoy a morning sunrise could be arrested for trespassing. Exacerbating the problem is that the Colonial Ordinances include no provisions for access to the intertidal zone. The accessibility of public beaches has already been declared to be in "a crisis", nevertheless those which are privately owned are increasingly restricting public use (Mass. House Report #6611, 1975). While the entire intertidal area may be open for certain uses, it becomes ludicrous when the number of perpendicular access points is limited. It is clearly difficult to fish at the seashore if there is no access to the ocean. The situation arises when large areas of uplands are all privately owned and allow for no access to the intertidal zone. In affect, the ordinances create a patchwork of coastline which can be enjoyed by the pubic with extensive parcels of private properties separating them. The implication is that an owner of a small coastal property could use his/her legal right and restrict all lateral passage in the intertidal area except for "fishing, fowling and navigation" even if both adjacent beaches were publicly owned.

Legislative attempts have been made to allow more open use of the intertidal areas. Since 1974, a bill (Mass. House #481, 1974), has been introduced at least three times to the Massachusetts Legislature proposing the free "public on-foot free right of passage" to cross privately owned intertidal properties. This bill has repetitively failed to become law because of the Justices' opinion that such a law would represent an unconstitutional "taking without compensation" (MCZM, 1985).

After 345 years of precedence and the recent supporting opinion, it seems that the Amendments to the Colonial Ordinances are steadfast in Massachusett's legislation. Ironically, the "right of passage" bill may be responsible for more restrictive enforcement of private property rights. Coastal owners are more aware of their property rights, and as property values rise, they are more eager than ever to keep the public off of them.

The only reprieve in the State's coastal laws involves the dominion and control over development in public trust lands. Even though the State has granted many submerged lands into private ownership, they are not exempt from the public trust. In 1979, the Supreme Judicial Court concluded that such grants can be made when serving the public trust, and the rights included with these grants can be revoked if the public trust is no longer served (Boston Waterfront Redevelopment Corp. v. Commonwealth, 1979). This case involved the filling of submerged lands in Boston with the intention of eventually building shops, offices, restaurants, and condominiums. The court ruled that the title to the disputed property was subject to the condition that it be used for the public trust.

Partly due to the implications and publicity of the 1983 case, the State Legislature adopted tight new rules restricting development and licensing of tidal and submerged lands under the Waterways Licensing Program (MGL C. 91, 1984). Because these areas do come under the public trust, irrespective of the colonial ordinances, development can be more strictly regulated than under other regulatory programs such as wetlands protection and local zoning. The

1983 Amendments of the Waterways Licensing Program integrate the public trust doctrine by establishing uniform procedures for licensing activities which take place below the accepted high water mark. The Amendments generally prohibit filling of tidelands for non water-dependent uses. They also require a license fee, as well as substantial conditions relevant to increasing public access to compensate for the private rights granted in the license. However, most previously filled tidelands are located in urban and suburban areas, and other new permits are expected to be very limited. Thus, mitigative conditions imposed are usually on areas which had previously lost their open space qualities due to earlier development. Therefore these Amendemnts will not lead to any significant increases in open space in areas which are important for either wildlife habitat or recreational activities.

Overall State efforts to allow more public access and use in coastal areas have been negligible due to the upholding of the Colonial Ordinances. Continuing coastal development coinciding with increased interest in marine recreation will undoubtedly lead to more exercising of private property rights on an already restrictive coast.

Protected Open Space in Massachusetts

Massachusetts has an extensive history of preserving and protecting open space. These efforts have traditionally been an informal partnership between municipal, state, and federal agencies, and non-profit organizations. Each land protection program has its own priorities directed towards different types of land, such as urban parks, river banks, and coastal accessways. Numerous growth management techniques are also employed in protecting open space. These techniques include zoning, fee-simple acquisition, subdivision regulations, and environmental legislation.

While governmental agencies and non-profit organizations continue efforts involving growth management and securing open space, their ability is limited due to low funding, rising land costs and the pace of development throughout the State. Even with many innovative ways of protecting open space, the rate of protection has not kept pace with the rate of development. Protected properties consist of those that are expected to stay in preservation, conservation, recreation, and other open spaces for the foreseeable future. As of 1986, Massachusetts had a total of approximately 558,268 acres of protected open space spread out throughout the State (Greenbaum and O'Donnell, 1987) (See Table 4). At that time, it worked out to just less than 1/10 an acre for every person in the State. The rate of land conservation has been averaging about 5,400 acres per year since 1950, but the rate of development has proceeded at 18,000 acres per year (Greenbaum and O'Donnell, 1987).

TABLE 4

ACRES OF PROTECTED OPEN SPACE IN MASSACHUSETTS

	1970	1980	1986
Federal Agencies			
National Park Service	45,000	45,000	45,000
U.S. Fish and Wildlife	11,775	11,775	11,775
subtotal	56,775	56,775	56,775
State Agencies			
Dept. of Environmental Man.	236,340	252,740	265,000
Dept. of Fish and Wildlife	24,716	43,719	52,000
Metropolitan District Comm.	13,600	14,000	15,000
State Self-Help Program	9,214	27,975	33,198
Dept. of Food and Agricul.	-	-	16,000
Dept. of Environmental Quality Eng. (Aquifers)	-	-	700
subtotal	283,870	338,434	381,898
Private Non-Profits			
Trustees of Reservations	10,791	20,619	23,656
Massachusetts Audubon	7,174	12,580	15,899
Appalachian Mountain Club	30	2,270	4,490
Berkshires Nat. Res. Council	-	3,256	4,256
Essex County Greenbelt	556	2,017	3,457
Martha's Vine. Cons. Society	4,200	6,237	6,500
Sudbury Valley Trustees	771	1,044	1,318
Nature Conservancy	123	325	679
Nantucket Cons. Society	2,217	5,437	7,700
Other Land Trusts (est.)	7,500	14,500	17,500
subtotal	33,382	68,285	85,455
Local Government			
Land Owned (est.)	16,300	17,600	21,000
Conservation Restrictions	-	9,200	13,140
subtotal	16,300	26,800	34,140
Total Acres Protected	390,327	490,294	558,268

Source: Massachusetts Audubon, 1987.

Ownership of coastal frontage and uplands is a fundamental part of many of the land protection programs in Massachusetts. Coastal land protection programs and legislation are especially important because over 75 percent of the State's population live within a one half hour drive to the shore (MCZM, 1985). Presently, the State's coastline of 1,342 miles has a total of 358 miles within 648 parcels protected from development (MDEM, 1988) (See Table 5). These properties are owned by municipalities, federal and state government as well as numerous non-profit organizations. Of even greater importance is the fact that as of 1980 it was estimated that only 87 miles of the entire coast remained undeveloped and unprotected, which leaves only limited opportunity to protect additional properties (MDEM,1980).

Subsequently, many protected waterfront parcels are often not located in areas which are optimal for active public usage; nor are they evenly located throughout the coast (See Table 6). For example, about 32 percent of these properties are located on islands which are only accessible by boat (MDEM, 1988). While these island locations act as good habitat for ecological preservation, they offer relatively little direct public use except for the few with a public ferry service. Similarly, the location of other parcels discourage public use because of the lack of parking or accessways. This situation is often

TABLE 5

OWNERSHIP OF PROTECTED COASTLINE

	Miles of Coastal Frontage	Protected Frontage as a % of Total Coastline
Municipalities	123.5	35%
Federal Govt.	97.1	27%
Nonprofit Org.	69.5	19%
Other	4.5	1%

Source: MDEM. Profile of Land Ownership along the Massachusetts Coast, 1988.

TABLE 6

PROTECTED COASTAL FRONTAGE BY REGION

Region	Total Coastal Frontage (miles)	Protected Coastal Frontage (miles)	Protected Frontage (percent)
North Shore	192.8	73.8	38.3
Metro-Boston	100.8	33.6	33.3
South Shore	184.3	28.6	15.5
Cape Cod	378.0	139.0	36.8
Buzzards Bay	212.3	30.4	14.3
Islands*	274.1	51.8	18.9
Total	1,342.3	357.7	26.6

* Martha's Vineyard, Nantucket, Elizebeth Islands

Source: MDEM. Profile of Land Ownership along the Massachusetts Coast, 1988.

found on coastal frontages which are dedicated to conservation rather than recreation where the objective is to protect unique natural resources on the shore. Likewise, other properties indirectly discourage usage because they are either too far away from population centers, or are those which have little aesthetic value, such as a vacant lot on a visibly polluted section of Boston Harbor.

Federal Open Space Protection

The federal government presently owns approximately 57,000 acres of protected open space in Massachusetts (Greenbaum and O'Donnell, 1987). This property is broken down into holdings by the National Park Service (45,000 acres) and the U.S. Fish and Wildlife Service (11,775 acres). Over 95 percent (43,500 acres) of the National Park Service property is located within the Cape Cod National Seashore. In comparison, the Fish and Wildlife property is more evenly spread throughout the State.

Although neither of these federal agencies have reported any major acquisitions since 1980, the federal government funds State Programs for protecting open space. The Federal Land and Water Conservation Fund provides up to a 50 percent reimbursement to the State for acquiring and developing land for outdoor recreation. Over the past 25 years, Massachusetts has received 78 million dollars to acquire nearly 4,000 acres of land and to renovate hundreds of parks. More recently, federal support has been reduced. In 1979 alone, state-run programs received a total of 9.6 million dollars. Since 1980, the yearly average has been about only one million dollars (Blaustein, 1988). Reductions of this magnitude certainly deter efforts by the State to continue with acquisition programs.

Less direct forms of federal protection of open space exist via different pieces of environmental legislation, under the auspices of various federal agencies. The Endangered Species Act (United States Congress, 1973) has funds available for land used for the protection of species which are endangered, either on a global or continental scale. However most species which are on the Massachusetts endangered or threatened lists are not on the federal list and do not receive federal funding (See Appendix 1). Subsequently, only 184 acres have been acquired in Massachusetts in the last 15 years through funding under this Act (Leahy, 1988).

The basis for much of the current coastal land-use protection and regulatory programs is found in the federal CZM Act. However, this federal legislation was written with the intention of being neutral in respect to environmental protection verses development. The Act was partially motivated by high rates of coastal development and the subsequent loss of environmental quality (Healy, 1985). In order to remain in a neutral standing the Act was to give "...full consideration for ecological, cultural, historical and aesthetic as well as economic development" (United States Congress, 1972). State programs are required to incorporate this language and scope into their coastal programs. This inclusion of "economic development" managed to retain political leverage for developers following the passage of this comprehensive coastal program.

One way in which the CZMA managed to indirectly influence the protection of coastal properties was through the consistency provisions. Authority was granted to states with federally approved coastal programs to reject federally funded or permitted projects within its coastal zone if they were found to be inconsistent with the provisions of the State Program. The consistency provisions have been subsequently utilized in Massachusetts to prohibit the construction of a four-lane highway through Cape Cod, as well as prohibit federally funded sewer extensions beyond the area which was needed to prevent coastal water quality problems (Ris, 1982). While these actions may have prevented unwanted development at the time, they are by no means a permanent solution to preventing development of these properties.

In addition to the CZMA, both the National Environmental Policy Act (NEPA) (United States Congress, 1969) and the Federal Water Pollution Control Act (United States Congress, 1972), have provisions which take into consideration aesthetic, and visual resources. Since much of the coastal zone is generally considered "aesthetically pleasing", the provisions often do little more than act as guidelines and goals which may only slightly change a proposed project in order to protect these qualities. They in affect do not always play a significant part in preventing coastal development because "consideration" does not always necessitate that a project be changed in order to incorporate visual resources.

The most recent federal effort of coastal growth management in Massachusetts comes under the National Estuary Program (NEP). Buzzards Bay and its surrounding coastal uplands in southern Massachusetts have been under federal analysis since 1985, and in January of 1988 were designated by the NEP as an estuary of national significance. The Buzzards Bay Project is a formal partnership between the Environmental Protection Agency and the Commonwealth of Massachusetts. One of the goals of the NEP was the creation of a Comprehensive Conservation and Management Plan (CCMP), completed in 1990. This document outlines the management options in and around the Bay. Because pollution to the Bay is presently the most critical problem, the plan will make recommendations to local, state, and federal agencies for control of pollution via the management and regulation of land-uses within the Buzzards Bay watershed.

State Protection

State efforts to protect open space in Massachusetts have been strong throughout the decade with over 650 million dollars earmarked for open space preservation and related programs. In 1983, Massachusetts became a national leader in open space preservation by approving a precedent setting 162 million dollar open space bond issue (Environmental Outlook, 1988). These funds lead directly to the purchase and/or protection of 38,000 acres of land. Subsequently, another 250 million dollar open space bond was proposed in a bill by Governor Dukakis in October of 1987 (Massachusetts Legislature, 1987b). The Bill went through numerous draft forms in debate between House and Senate priorities. Non-profit environmental organizations lobbied hard to pass the bill. The final law (Chapter 564) which passed on December 9, 1987, appropriated just over 500 million dollars for "restoration, rehabilitation, preservation and acquisition projects throughout the commonwealth" (Massachusetts Legislature, 1987). The Legislature passed the bill which had earmarked funds for over 50 programs managed by several agencies within the Executive Office of Environmental Affairs. Each of these programs has specific objectives, the majority of which involve the protection of open space.

Even without the latest state funding, state-owned land and development rights represent the majority of all protected open space throughout Massachusetts. Open space in the Commonwealth is administered by different state management agencies based on specific preservation goals. Overall, state supported programs have protected land holdings which total close to 382,000 acres (See Table 4, p. 49). Of this total approximately 70 percent is under the jurisdiction of the Department of Environmental Management, which between 1970 and 1986 purchased an additional 28,660 acres. The remaining 116,000 acres were the result of acquisitions by the Department of Fish and Wildlife (52,000 acres), Metropolitan District Commission (15,000 acres), Department of Food and Agriculture (16,000 acres), Department of Environmental Quality Engineering (700 acres) and the State Self-Help Program (33,198 acres) which funds municipal acquisition of open space. Evidence of ongoing state supported programs is clear with the addition of over 98,000 acres of protected open space since 1970 (Greenbaum and O'Donnell, 1987).

In addition to statewide preservation of open space, several state land-use programs are directed specifically towards coastal uplands. The most direct approach is the Department of Environmental Management's (DEM) Coastal Land Acquisition Program. The coastal acquisition program began in 1980, when the administration of Governor Edward J. King in its Capital Outlay proposal requested and received legislative approval for a one million dollar bonding authorization for the acquisition of coastal properties by DEM. The original plan identified over 50 sites which were suitable for recreation/conservation and proposed a long-range cooperative effort between the state, municipalities, individuals, and non-profit organizations to carry out the directives. The Plan also indicated that far more funding and innovative land preservation techniques would be required to fulfill the stated goal of acquiring two to three sites each year starting in 1981.

As of 1986, the Coastal Acquisition Program had exceeded its original goal with over 40 sites purchased in a six-year period (See Table 7) (MDEM, 1987). Spending over 17 million dollars, the State added 1,163.5 acres of coastal uplands to its portfolio of protected properties.

Even with more acquisitions than originally expected, the list of potential coastal acquisitions grew. Development pressures for these same parcels was likewise growing. The problem, in early 1987, was a lack of funding sources for any state open space acquisitions. It was at this time that the largest open space bond issue passed. The bond provided funding for at least sixteen state programs which could potentially lead to the acquisition of coastal properties. These funds totaled 275 million dollars, of which 40 million dollars was explicitly earmarked for coastal acquisition within section 19 of the Act (MGL C. 564, 1987). Described below is the language and intent of the coastal funds.

TABLE 7

COASTAL LAND ACQUISITION TOTALS 1980-1986

Year	Acres	Cost	Average Cost per Acre	No. of Properties
1980	52.6	-	-	2
1981	80.2	$1,092,314	$13,981	7
1982	401.9	$6,287,000	$15,646	9
1983	362.0	$2,564,100	$ 7,089	7
1984	153.8	$2,112,500	$25,575	5
1985	0.3	$ 326,000	$516,280	2
1986	112.7	$4,672,768	$41,462	8

Source: MDEM. Coastal Land Acquisition Strategy, Division of Planning and Development. 1987.

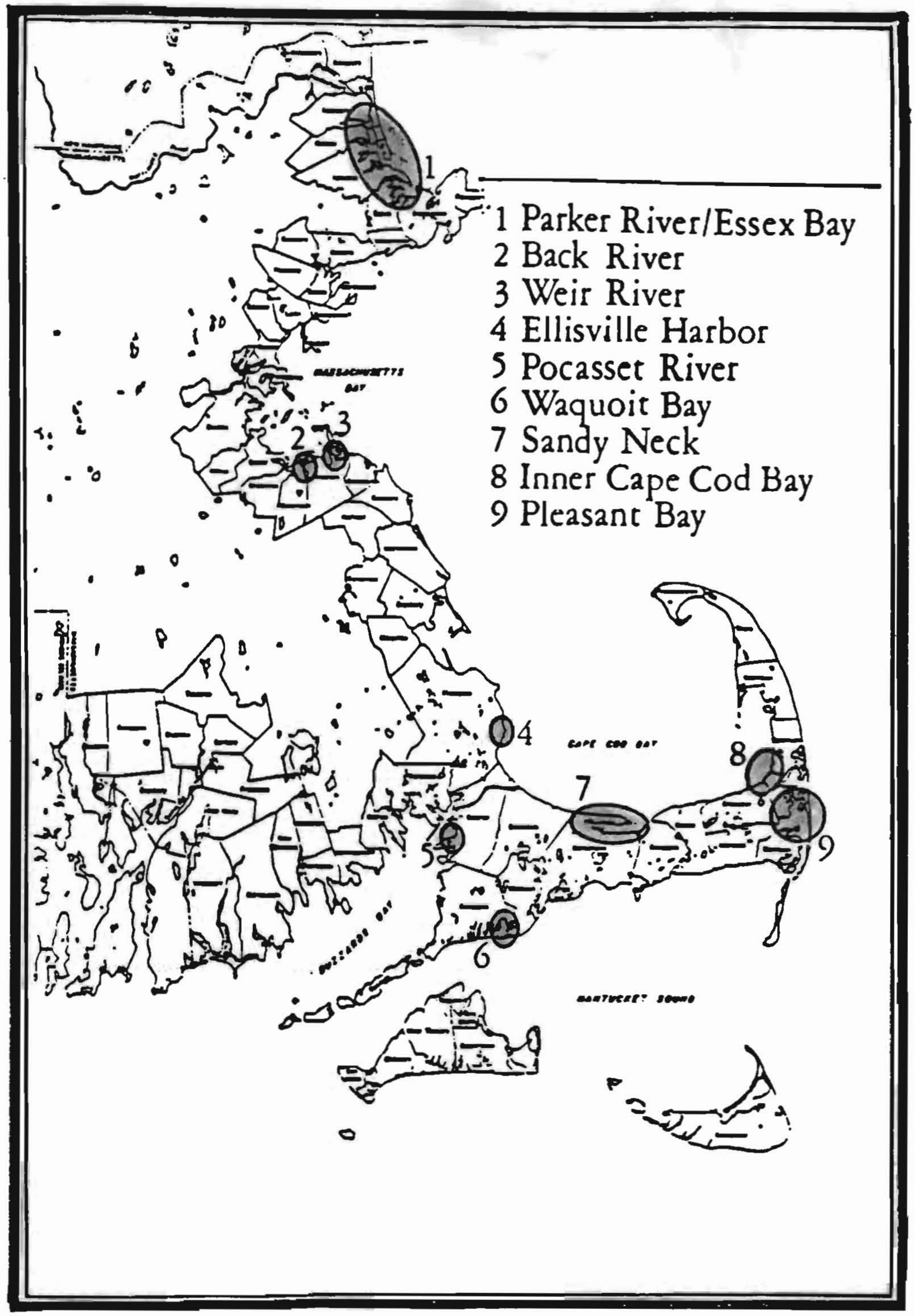
> "...a sum not exceeding forty million dollars for the acquisition of land and easements in land fronting saltwater, whether containing beaches or otherwise, and associated costs herewith, for the purpose of continuing a long-term program of providing and ensuring conservation of, and public access to, saltwater front properties; provided, however, that said commissioner may expend funds appropriated herein for the acquisition of land and easements in land fronting freshwater rivers with the coastal zone and associated costs herewith" (Chapter 564, Sec. 19, 1987).

Even though the recent statewide financial crisis has caused problems for allocating some of the funds, the recent funding did allow for important acquisitions of coastal properties. One 53-acre property in Edgartown was taken by eminent domain and valued by the State at four million dollars.

The Area of Critical Environmental Concern (ACEC) Program, acts to control excessive growth and development within certain areas of the coastal zone. This program was established in 1974 as part of legislative reorganization of state agencies dealing with natural resources, environmental matters, and conservation (MGL C. 21A, 1978). It does not require new permitting and administrative programs, but functions through a greater review process by existing agencies and the public for activities proposed in an area designated as an ACEC. Regulations of many of the State's environmental programs have sections pertaining to ACECs. For example in order to protect relatively unaltered estuarine areas along the coast, the State Coastal Zone Management Program has used

FIGURE 5

COASTAL AREAS OF CRITICAL ENVIRONMENTAL CONCERN



Source: Bliven, 1987.

include conservation restrictions or zoning bylaws to accomplish open space objectives. Municipal conservation easements are a technique which are increasingly used for this purpose. For example, by 1987, over 13,000 acres were protected by conservation easements, while practically none existed in 1970 (Greenbaum and O'Donnell, 1987).

Throughout Massachusetts, municipal governments play a large role in practically every development project. Most municipalities have either full- or part-time planners, engineers, public health officials and conservation commissions. Part of their jobs is to ensure that any particular construction project meets local development ordinances and laws. Local citizen groups also have the opportunity to participate in the decision-making process by making recommendations and comments which may act to sway the final decisions and conditions of city officials. Massachusetts communities are known for their town meetings which establish "home rule" in their governing system. Only in difficult decisions, such as development projects which involve sensitive resources areas, do local officials feel it necessary to incorporate state agencies in the permitting process (Rosner, 1980). In most cases, respective regulations compliment each other with little explicit interaction needed.

Environmental attitudes can vary from one municipality to another, and the State gives a great deal of discretionary authority to let each municipality make their own decisions (Healy, 1985). This system may be most appropriate for coastal communities, because they often perceive State Coastal Programs as a tool of the "environmentalists" (Rosner, 1980). Not all communities are necessarily pro-environment and some favor local development to strengthen their local economy. Regardless of what the outcome of a development decision, the rationale behind local regulation and planning has traditionally been to ensure that real estate captures its highest value (Zwicky, 1973). It is this incentive which compels local affiliates to apply many innovative approaches when they conclude that the communities best interest is to keep a property undeveloped and open to public use.

Zoning ordinances are the most common method employed by municipalities to indirectly restrict development. It was ruled for the first time by the U.S. Supreme Court in 1926 that there was no need to approach the "taking without compensation" issue. In this precedent setting case, the Court ruled that a town may zone for the purpose of maintaining the character of a residential community by separating industrial, commercial and residential development (Euclid V. Amber Realty Co., 1926). The municipal power to zone in Massachusetts is granted by the State under the police power for the public health, safety, and general welfare (MGL Ch. 40A). Zoning powers allow for a town or city to create historic and environmental districts, or even rezone for nonresidential use of storm damaged coastal property (Brautigam, 1985). Zoning is only permissible within the scope of police power, which allows for the passage of laws for the "general-welfare" of a community and not just to create open space because it is desirable. Subsequently, changes in zoning are often challenged on the basis of a "taking without compensation". Also, the need for affordable housing has been ruled to invalidate restrictive residential zoning (Ziegler, 1986). The weakness in zoning results from the fact that variances may be permitted at the discretion of local authorities. Variances may be granted not withstanding the zoning category, because adverse impacts can often be mitigated with technological solutions such as extending sewer lines instead of relying on conventional on-site septic systems (Melious, 1987). Zoning thus gives a general indication of what types of development may proceed at a given location; but, it provides no assurances.

Transfer of development rights, differential assessment, and tax deferments are all tools used on the municipal level to prevent development. These programs all have similar problems which limit their usefulness in coastal areas. An underlying problem in these programs is that financial incentives to sell and develop coastal property are just too high to persuade owners to participate (Keene, 1977). Also, the programs usually require a landowner to participate in these programs for a specified number of years after which time the land may again become available to development; thus, only delaying the problem of overdevelopment. Each of these methods are only utilized on a voluntary basis by the property owners, and then only if a particular municipality has made such a program available. For example, a transfer of development rights program has yet to be used in Massachusetts, but has been shown to have problems in other states when applied to coastal areas (McGilvary, 1983). Differential tax assessment is permitted in the State, but only for retaining the use of the property for agriculture (MGL C. 61, 61A, and 61B). This has very little application in coastal areas since most agricultural activity takes place away from the shore.

Additional methods possible, as alternatives to fee-simple acquisition, are dedications and exactions of property as a condition for zoning or subdivision approval of a new development. However, in Massachusetts, a municipal planning board cannot require the landowners to give up any land for public use without compensation (MGL C. 41, 1953). The courts have ruled that dedications and exactions must be sufficiently related to the demands created by the development (Collins V. Bloomington, 1976, and Nollan V. California, 1987) This condition may require a developer to dedicate land for roads, schools and sidewalks, but not for permanent open space or public accessways to the ocean (MGL C. 41,). One exception to this is that open space and parks may be required as a result of the development and not due to a need by the community (Brautigam, 1985) The problem with this approach is that it may lead to only small, possibly insignificant parcels directly related to the development, such as retaining a certain number of trees within the project plans. More detailed examples of municipal programs directed at growth control within the coastal zone will be discussed in Chapter V, which includes a outline of the effectiveness and results of growth management in Gloucester.

Non-Profit Organization Protection

The many non-profit organizations active in Massachusetts have been an important factor in protecting open space throughout the State. Their holdings total over 85,00 acres (See Table 4, p. 49). In order to ensure the protection of specific parcels, non-profit organizations often coordinate their activities with state and local agencies (Brown, 1987). For example, although four state agencies had committed to buying High Head in Truro, a unique tract of coastal property, they were unable to come up with their share of the 2.7 million dollars in time (Dumonoski, 1987). Because state monies were temporarily exhausted, the Nature Conservancy, a private organization, bought it to prevent it from being developed. This relationship is important because governmental agencies usually have to follow a time consuming protocol in order to come up with the funds to buy property. During this time, property can be vulnerable to development. In some cases in order to ensure the protection of such property, non-profit organizations will buy the property under an agreement that the state or municipality will reimburse them when funds become available. This unique relationship exists because the non-profit organizations do not have to go through all the government "red-tape" in order to release funds.

CHAPTER IV

RURAL WASTEWATER TREATMENT

Conventional Septic Tank Systems

Conventional septic tank systems are the most widely used on-site sewage treatment system in the United States. They are used in almost all locations where municipal sewering is not available. In fact, it is estimated that over 24 percent of the nation's population is served by septic systems (Alford, 1979).

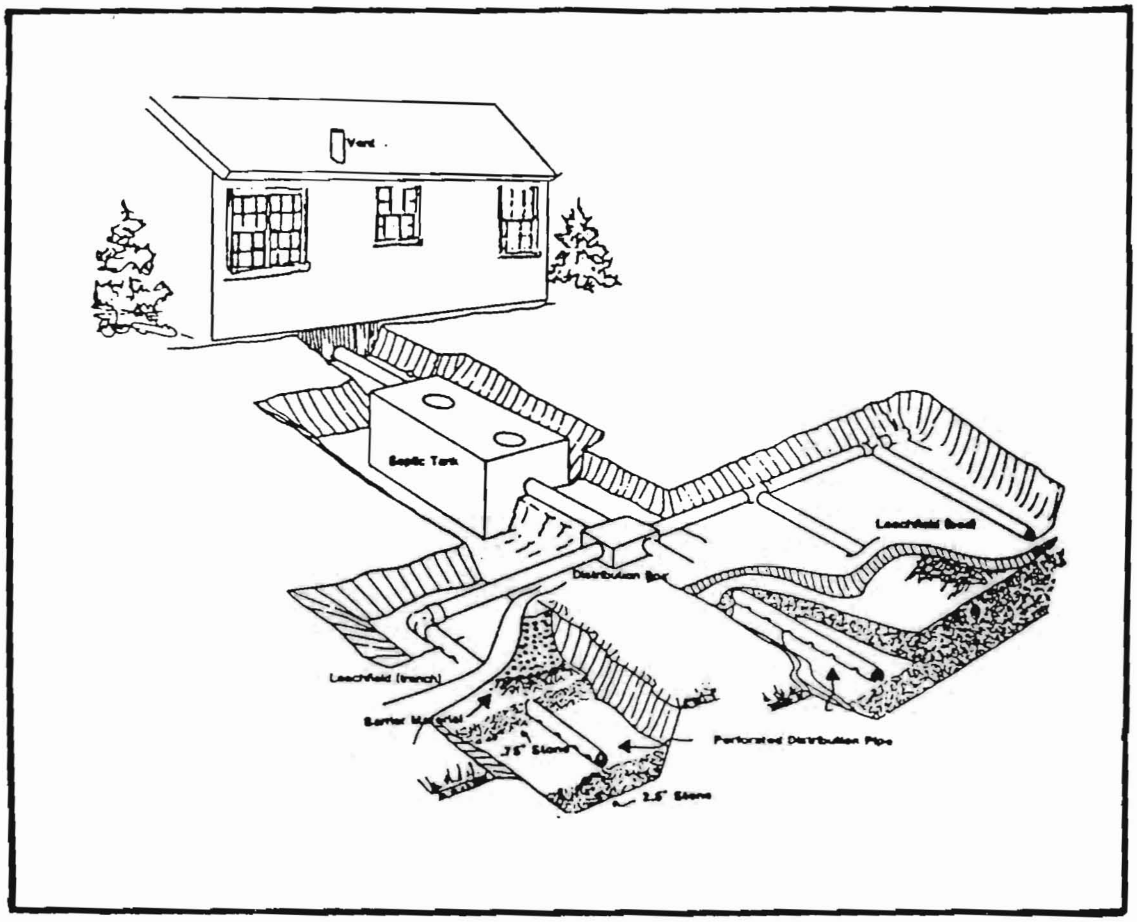
Septic Tank Operation

The operation of conventional septic tank systems have changed very little over the past century. They typically consist of a water-tight tank, distribution chamber, and a subsurface leaching field (See Figure 6). It is a rather simple configuration which offers a viable alternative to sewage treatment plants.

Treatment begins in the septic tank where wastewater is retained long enough for heavy solids to settle to the bottom and lighter materials to float to the surface. Tanks are designed with a retention time between 24-48 hours, and capacity is dependent on design flow. Massachusetts

FIGURE 6

TRADITIONAL SEPTIC SYSTEM



Note: Typical septic system with trench and bed leachfields. This cross section shows the layers of materials used in the construction of trench and bed leachfields.

Source: Lund, 1988.

regulations require a minimum tank capacity of 1,000 gallons and not less than 150 percent of the design flow (310 CMR 15.06). Tank capacity must be increased to 200 percent of design flow if garbage grinders are to be used in combination with subsurface disposal (310 CMR 15.06 (2)). The design flow is based on factors such as the estimated amount of waste-water to be produced and composition of the waste-water. The design flow for single and multiple dwellings is calculated by assuming 110 gallons of effluent per day per bedroom (310 CMR 15.02).

The environment inside the tank lacks oxygen so predominantly anaerobic microorganisms can survive and digest organic compounds. Dead microorganisms flocculate and join with the sludge on the bottom of the tank, where it can be periodically pumped out and disposed of along with the lighter floating materials. Tanks generally need to be pumped out every two to three years or when the sludge fills approximately one third of the tank. The filling rate depends on how often the system is used. Wastes are disposed of at a municipal treatment facility where they can undergo additional treatment.

Effluent exiting from the septic tank is only partially treated before entering a distribution box which is connected to a series of perforated pipes. The pipes allow for a even dispersal of the effluent into a subsurface leaching field where additional treatment processes can naturally occur. Aerobic organisms living in the soil digest organic matter entering the soil from the tank. Chemical and physical properties of soil particles adsorb, absorb, and precipitate sewage nutrients, metals and pathogens.

Septic System Performance and Limitations

When a septic system is properly designed, constructed, and operated, it can provide as efficient treatment as a centralized treatment plant (USEPA, 1980). Under these conditions, it can be expected to have an effective life of over 30 years, after which it is necessary to reconstruct the leaching field (USEPA, 1978). In practice, however, a wide range of problems plague septic systems. When chronic problems arise, they can threaten deterioration of both ground and surface water quality. The problems are due to mechanical malfunctions, poor soil conditions for subsurface disposal, and inappropriate owner use such as disposing of cooking oils or plastics into the system.

Most problems with septic systems are associated with clogged soils in the leaching field. Poor soil conditions, a high water table, broken pipes, sludge build-up and other circumstances can result in a clogged leaching field. Once a system becomes clogged, slow draining pipes, noxious odors and surface liquids quickly follow. Repairs are usually possible but can be expensive. They can be as simple as cleaning out the septic tank and pipes or as difficult as digging out the entire leaching field and replacing with fresh gravel.

Records of septic system failures are sometimes high. The results of one study, which evaluated over 5,000 septic systems, documented an overall eight percent failure rate of which 66 percent was due to leaching field failures (Gross and Thrasher, 1984) (See Table 8). Such apparent unreliability is often responsible for poor public acceptance of septic systems.

Massachusetts Regulatory Control

In 1977, the Massachusetts Legislature promulgated Title V of the State Environmental Code (310 CMR 15.00). It was enacted to provide minimum standards and regulations for the design and installation of subsurface sewage disposal systems.

Title V regulations are not administered by the State, but by the board of health of any city, town, county or other legal entity within the State. A permit issued by the board of health is required for the "location, construction, alteration, repair, or installation" for all individual sewage disposal systems (310 CMR 15.02 S.1). Subsurface disposal is prohibited where municipal sewage systems are accessible (310 CMR 15.02 S.1).

The Boards of Health have full jurisdiction over all systems which produce less than 15,000 gallons of effluent a day, unless a sewage treatment facility is proposed. When a proposal includes a sewage treatment facility or exceeds the

TABLE 8

SEPTIC SYSTEM MALFUNCTION TYPES

Failure Type	Number	Percent of Failures	Percent of Total Installations
Pump Failure	58	12.7	1.1
Plumbing Problem	40	8.8	0.8
Broken Pipe	56	12.2	1.1
Drainfield Failure	303	66.3	5.8

5,223 Total Systems
392 Malfunctioning Systems
457 Malfunctions (including recurrences)

Source: Gross and Thrasher, "Causes, Correction and Prevention of Septic Tank-Absorption System Malfunction," 1984.

15,000 gallons per day minimum, the board of health cannot issue a permit until approval by the Massachusetts Department of Environmental Protection (DEP) (310 CMR 15.02 (1)). Approval by the DEP is independent of the Board of Health permit under Title V. Thus, even with DEP approval, a developer/applicant must still still obtain a permit from the local board of health.

Local board of health regulations can exceed state requirements for subsurface sewage disposal systems. Under Title I of the State Environmental Code, local boards of health are empowered to promulgate "reasonable" health regulations which are stricter than the state minimums (310 CMR 11.02). In addition, they also have the authority to grant variances (310 CMR 15.20). The State does limit the use of variances by allowing them under only two circumstances: 1) "the enforcement thereof would do manifest injustice"; and 2) "protection required under this Title can be achieved without strict application of the particular provision." The State however, reserves the right to revoke, modify or suspend variances granted by a local board of health (310 CMR 15.21).

The Title V regulations which refer to the actual disposal of effluent into the ground are most likely to be responsible for a permit denial. Septic tank technology is relatively simple and it is not difficult to meet the specifications. However, the technical requirements for leaching effluent into the ground are much more dependent on site specific conditions and every disposal system must have a reserve leaching area of at least equal capacity to meet all specifications (310 CMR 15.02 S.22).

There are a wide range of soil characteristics, all of which can affect the capability of the system to adequately treat the effluent. The soil beneath the lowest point of excavation of a leaching field must at a minimum consist of four feet of naturally occurring pervious material (310 CMR 15.15 S.7). An additional four feet is required between any leaching field and the maximum ground water elevation (310 CMR 15.15 S. 3). A percolation test is required to measure how quickly liquid passes through the soil. A leaching field will not be permitted if the percolation rate is slower than 20 minutes per inch (310 CMR 15.15 S. 1).

Setback distances are also a major impediment to the permitting of subsurface disposal systems. The State has determined minimum distances from many municipal infrastructures such as wells, property lines, and water bodies (See Table 9). The regulations also stress that the setback "distance shall be increased where required by conditions peculiar to a location" (310 CMR 15.11 S.3).

Small Scale Wastewater Treatment Plants

Small scale wastewater treatment plants (SSWTP) offer a viable alternative for development which would have otherwise been restricted to using either municipal

TABLE 9

SEWER AND SEPTIC SYSTEM SETBACK DISTANCES

Component	Septic Tank (feet)	Leaching Facility (feet)	Sewer (feet)
Well	50	100[1]	[3]
Water supply line	[4]	[4]	[4]
Cellar wall or pool	10	10	-
Resovoirs & tributaries	50[2,5]	100[1,2,5]	[5]
Watercourse	25[2,5]	50[2,5]	[5]
Subsurface drains	25	25	-
Leaching catch basin or dry well	-	25	-
Downhill slope measured from the top of the leaching facility	150 times the slope (expressed as a fraction)		

1 100 feet is a minimum acceptable distance and no variance shall be granted for a lesser distance except with prior written approval of the Department of Environmental Protection.

2 All distances shall be measured from the average of the mean annual flood elevation in inland areas and from Mean high Water in coastal areas.

3 10 feet if constructed of durable corrosion resistant material with watertight joints, or 50 feet if any other type of pipe is used.

4 It is suggested that the disposal facilities be installed at least 10 feet from, and 18 inches below water supply lines. Wherever sewer lines must cross water supply lines, both pipes shall be constructed of class 150 pressure pipe and should be pressure-tested to assure watertightness.

5 The applicant should be should be aware of his obligations to comply with the requirements of the Wetlands Protection Act, G.L., c. 131, s. 40.

Source: MDEQE. CMR 15.03(7).

sewering or ISDS. The technology is readily available and can be adapted to accommodate almost any size development. Long-term monitoring data, however, is lacking and there is great concern over the adequacy of existing state regulations.

Technology and Design Guidelines

Over the last two decades, there has been extensive research in the technology and design of SSWTPs. The goal has been to design reliable and cost effective sewage treatment for small developments where city sewering is not practical. Recently, many commercial firms have designed and made available a multitude treatment systems adequate for small developments. These systems usually are a modification and scaled down version of the technologies used in large municipal treatment plants. They commonly use the natural processes of aerobic and anaerobic organisms to treat the wastewater.

The following is a synopsis of the step by step processes commonly used at SSWTPs in Massachusetts. Included within these descriptions are some of the more important guidelines for construction and performance by the Massachusetts Department of Environmental Protection. Because of advances in sewerage treatment technology, the State updated the guidelines in 1989.

Collection system

The collection system is the first phase in the flow of effluent through any sewerage system. At this point, the effluent poses the greatest environmental risks because it has received no treatment at all. The collection system consists of a network of underground pipes to transport the raw sewage from the source (toilets, sinks, etc...) to the treatment plant. It must be designed and installed to overcome numerous obstacles such as winter freeze-ups, steep slopes, corrosion, and be placed far enough away to avoid close proximity to fresh water pipes. In addition, State requirements will not license or permit any collection system which allows overflows, rain water, surface drainage, and sump pump discharges to enter the system (MDEQE, 1988b).

Whenever possible, a collection system utilizes gravity to move the effluent to the treatment facility. Otherwise, when the sewerage must go up-hill, more expensive techniques are necessary such as pumps, lifting stations, and low pressure sewers. Because the DEP is concerned about susceptibility to mechanical and operator failure, non-gravity techniques are permitted only when absolutely necessary. The guidelines even stress that pumping stations must be safeguarded from physical damage to the extent that they remain operational during a 100 year flood (MDEQE, 1988b).

Primary clarification

Primary clarification is the second major process in SSWTPs. Primary clarification is basically the same treatment technology used at municipal primary sewerage treatment plants and removes about 30 percent of the organic loading (USEPA, 1980). It takes place in either large septic tanks or mechanically cleaned circular settling tanks. The effluent is first run through fairly large mesh screens to remove large objects such as plastics, pieces of wood, and rocks which could otherwise cause an obstruction further on in the process. The remaining solids enter into a garbage grinder to shred solids into more readily digestible particles. In order to remove the smaller particles, the tanks utilize the density of settleable solids and floating materials and allow for limited digestion of organic matter by anaerobic bacteria. The settleable solids and partially decomposed sludge settle on the bottom of the tank and accumulate. Floating materials such as oils and greases, called scum, rise to the top. Between these two layers is the partially clarified liquid which enters the next phase of the treatment system by flowing through openings specially designed to prevent any scum and sludge outflow. Depending on the particular system, sludge and scum are either periodically or continuously removed from the septic tank. In the case of removal of scum and sludge from mechanical clarifiers, the DEP calls for this to be done at least once per hour (MDEQE, 1988b).

State guidelines for primary clarification cover construction, disposal of wastes, and access for maintenance of the tanks. The focus of the guidelines, however, is on the capacities of individual tanks. Concern is that the tanks must be large enough to contain peak effluent flows, while adequately separating the solids.

Flow equalization

Flow equalization is a method to even out the flow entering the biological treatment tanks. Each treatment plant is designed to accept the volume of wastewater which is produced during a 24 hour period. However, wastewater flows are rarely constant and have wide variations throughout the day. Residential water use is usually highest in the morning before normal school and work hours, and again during early evening when people return home. It is it critical that neither excessive nor insufficient flows occur beyond the primary clarification phase because they may reduce the effectiveness of the remaining treatment processes. This can occur when the capability of microbial action to flourish during wide variations in effluent level is limited. Excessive flows lead to an overburden of clarified liquids, and periodic surges of sewerage may also cause scums and sludge to become responded and exit the septic tank mixed in with the clarified effluent. Under this condition, microbial action can not keep pace and may work more inefficiently due to the inhibiting effects of the oils, greases and non-organic particles. When the volume of effluent exiting primary clarification is too slow, a starved system may result due to the lack of nutrients for the microbes to feed upon. By monitoring and evaluating the periodic flow patterns, the equalization capacity of a treatment plant can be selected. This is accomplished by using a second tank which stores excessive flows and then is fed through the treatment plant via gravity or pumps throughout a 24 hour period. The size of these tanks is critical and the DEP calls for a minimum effective liquid capacity of fifty percent of the design flow for treatment plants that treat less than 40,000 gallons per day (gpd). In addition to a equalization tank being required after the primary clarification, the guidelines require one prior to all other treatment processes.

Aerobic treatment

The objective of aerobic treatment is to enhance the normal biological function of microorganisms in the presence of oxygen. The micro-organisms responsible are mostly bacteria, but also include algae, protozoa, rotifers and crustaceans (Autorol Corp., 1978). The processes used can remove substantial amounts of biological oxygen demand (BOC) and suspended solids that are not removed by sedimentation. The microbes remain in the sewage effluent following primary clarification. Here they are able to convert the suspended organic matter into cells and inorganic materials. By providing an adequate supply of oxygen, the bacteria can grow at much higher concentrations accelerating the natural process and increase its efficiency.

The important process in aerobic treatment is allowing the bacteria to convert the suspended solids into cell structures, which can then be separated and disposed of from the treated liquid. Treatment systems are engineered to allow for a wide variety of microorganisms to exist symbiotically. The diversity permits a variety of biochemical reactions which can react to variations in effluent as well as environmental conditions. The final microbial growth products can be expected to range from 30 to 60 percent of the dry weight of organic matter which enters the system (USEPA, 1980).

Each treatment plant is designed to accommodate a specific range of organic loading depending on the number and type of users. When excessive quantities of organics enter a treatment plant, the microbial action is not adequate, potentially leading to the release of intruded wastewater. Most of the organic load from residential wastewater treatment comes from human wastes and the use of garbage disposals (USEPA, 1978). Unlike human wastes which have undergone partial digestion, garbage disposal products have undergone none prior to entering the system. Hence, the permitting of many SSWTPs in Massachusetts precludes the use of garbage disposals.

Household chemicals poured down the drain cause another condition which can reduce the effectiveness of the microbial action (USEPA, 1977). The State presently requires that the monitoring for such contaminants be performed on an annual basis. Even though the dumping of many household products are prohibited, it is relatively unenforceable.

There are two general biological treatment systems which are commercially available for on-site application. These are: (1) suspended growth and (2) fixed growth systems. Each system is quite different mechanically, but both utilize the same biological processes to treat wastewater. In the suspended growth process, the microorganisms are suspended in the water, while the fixed growth system employs an inert media to which they may become attached. A rotating biological contactors (RBCs) arrangement is the most commonly used in the fixed media treatment system, while suspended growth systems usually employ the use of extended aeration activated sludge. Described below are the details of these two treatment systems.

rotating biological contactors

RBCs employ a series of rotating plastic discs mounted on a horizontal shaft (See Figure 7). The disks are partially submerged in the settled sewage and rotated at a rate of one to two revolutions per minute (rpm). At least 40 percent of the disks must be submerged at any time, and at least three series of disks are used for secondary treatment.

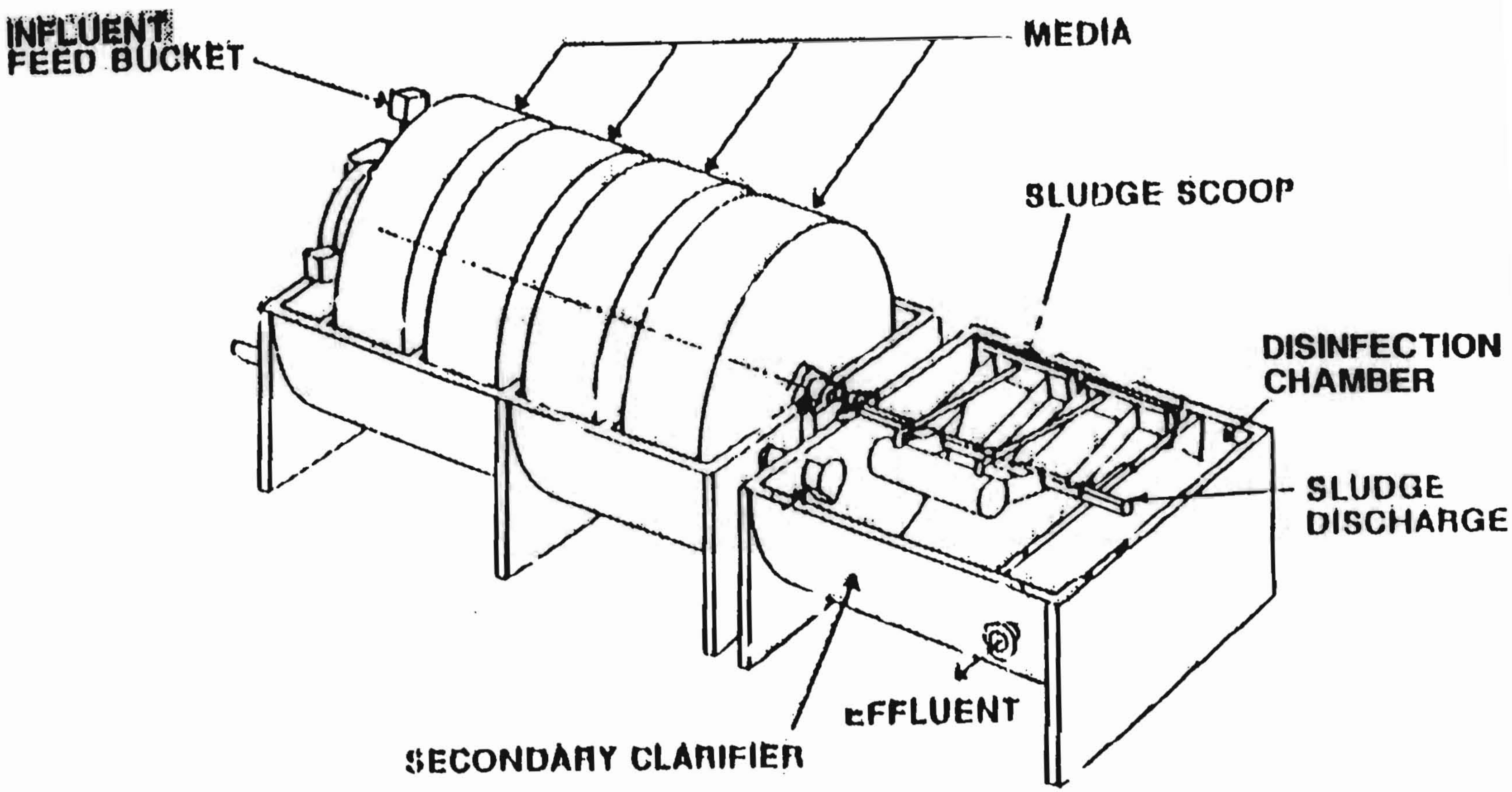
Aerobic treatment begins immediately when micro-organisms, naturally present in the wastewater, begin to adhere to the rotating surfaces. Growth on the discs continues by utilizing the organic compounds in the wastewater, and the aeration is provided as they rotate through the air.

The constant movement of the disks in and out of the wastewater causes the layer of organisms to grow in elongated shaggy strands. These growth strands provide a surface area larger than that available on the support structure, allowing increased space for biological activity. They also facilitate aerobically active growth by allowing suspended solids and dissolved oxygen to reach a greater portion of the organisms.

Approximately one week following start-up of the process, the disks are covered with about a one tenth of an inch layer of biomass. With the addition of more growth, the shear force exerted by the wastewater causes the excess growth to be stripped back into the wastewater. From here, the treated wastewater and stripped biomass move onto the next series of disks. Each series provides a progressively

FIGURE 7

DIAGRAM OF ROTATING BIOLOGICAL CONTACTOR PACKAGE PLANT



Source: Resource Education Institute, Inc., 1989.

more advanced degree of treatment, due to the differences in the biological composition growing on the disks. Exiting from the last series of disks, the effluent passes into a secondary clarifier.

The life expectancy of a RBC system can vary depending on construction materials used, general maintenance, and operator capability. The State requires the shafts to withstand expected stresses without failure for at least 20 years. It can be assumed that most other major mechanical parts are be designed to have a similar life span.

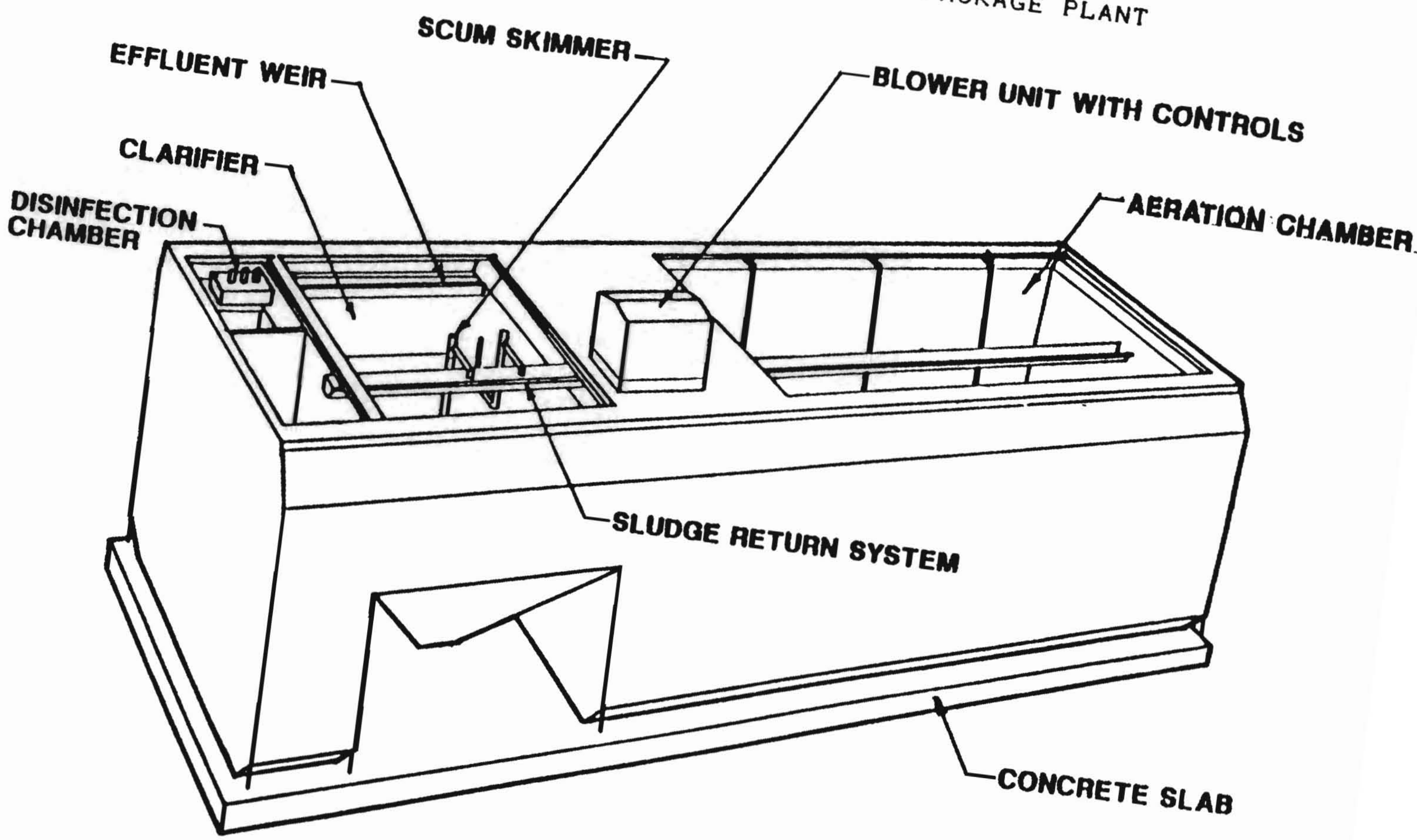
activated sludge system

The activated sludge process for residential wastewater treatment is the same as commonly used in most large municipal secondary treatment plants (See Figure 8). The biology is basically the same as with RBCs, except that microorganism growth takes place suspended in a series of aeration tanks. Aeration is supplied by blowers which discharge fine and course bubbles through air diffusers submerged in the tanks.

Unlike the RBC system, which is operated as a once-through process, the activated sludge system recycles all or portions of the separated biomass from a secondary clarifier back to the aeration tank. It also utilizes the residuals directly from primary clarification. This procedure is needed to supply the microorganisms required to start the treatment on the incoming raw sewage.

FIGURE 8

DIAGRAM OF ACTIVATED SLUDGE SYSTEM PACKAGE PLANT



Source: Resource Education Institute, Inc., 1989.

Ensuring the proper quantity of returned sludge to the aeration tank is important for adequate treatment. Also, the correct ratios of dissolved oxygen, proper temperature, and ph are all important for maximum efficiency.

Both the RBC and activated sludge systems can deliver comparable treatment to residential wastewater. However, as of 1989, the RBC process represented over 65 percent of the SSWTPs in use and close to 90 percent of all proposed systems in Massachusetts (See Table 10). This is attributable to the more complex technical aspects of the activated sludge process, and the ability of RBCs to withstand peak flows and its relatively low costs of operation.

Secondary clarification

The object of secondary clarification is essentially the same as with primary clarification; to separate the solids from the liquid. When the effluent enters the clarifier, it contains flocculated suspended matter and stripped biomass cultured during the aeration treatment process. The clarifier, which is essentially a settling tank, is designed to physically remove solids which settle on the bottom. Similarly, floating materials are removed by a skimmer, and clarified water passes through a discharge weir.

TABLE 10

EXISTING AND PROPOSED SMALL WASTEWATER TREATMENT PLANTS IN MASSACHUSETTS

Systems in All Towns	Condo's	Mixed Condo & other	Other	Subdi-vision	Total
Existing Systems					
Advanced Treatment, total	26	4	39	0	69
RBCs	17	4	24	0	45
Activated Sludge	9	0	15	0	24
Septic Systems >15,000 gpd	2	0	5	2	9
All Existing Systems	28	4	44	2	78
Proposed Systems					
Advanced Treatment, total	20	1	15	13	49
RBCs	18	1	11	13	43
Activated Sludge	2	0	4	0	6
Septic Systems, >15,000 gpd	0	0	0	0	0
All Proposed Systems	20	1	15	13	49
Systems in Partially Sewered					
Existing Systems					
Advanced Treatment, total	2	3	11	0	16
RBCs	1	3	7	0	11
Activated Sludge	1	0	4	0	5
Septic Systems, >15,000 gpd	0	0	3	2	5
Existing Systems in part. sewered towns	2	3	14	2	21
Proposed Systems					
Advanced Treatment, total	5	0	3	3	11
RBCs	5	0	2	3	10
Activated Sludge	0	0	1	0	1
Septic Systems, >15,000 gpd	0	0	0	0	0
Proposed Systems in part. sewered towns	5	0	3	3	11

Source: Young, Charlotte Holt, Small Privately Owned Wastewater Treatment Plants and Their Potential Use in Massachusetts Single Family Home Developments Thesis, Urban And Environmental Policy and Civil Engineering, 1989.

Unlike in the primary clarifier, the density of the much solids are very close to that of water and the settling rate is slow. Any turbulence in the water can upset the process and the tanks are designed to keep agitation at a minimum. The solids proceed to collect on the bottom; floatables are skimmed off.

A constant removal of solids is achieved in both a RBC and an activated sludge system. The only difference is that with RBCs, all the solids are removed for disposal, and with activated sludge much of the solids are returned to the aeration chamber. In theory, the liquid flowing from the secondary clarifier, called supernatant, is relatively clear, and up to an 85 percent reduction in total suspended solids can be expected from a properly operating system (ICF Inc., 1990).

Effluent filtration

Effluent filtration is used to minimize the suspended solids prior to discharge. It is important in preventing the subsurface effluent beds from becoming clogged due to high solid levels. An overburden of suspended solids can back-up the treatment process and lead to objectionable odors. State guidelines call for a minimum of two filters at all SSWTPs (MDEQE, 1988b).

Disinfection

Disinfection is used to destroy remaining pathogens, before the wastewater effluent is released into the environment. A number of methods are commercially available for disinfection. These include chlorination, iodine treatment, ozone, and ultraviolet light. Chlorination is the most commonly used method for use in SSWTPs. State requirements regarding disinfection are dependent on the method of final effluent disposal. If open sand bed or spray irrigation disposal is utilized, then the disinfection capability is required. When subsurface disposal is utilized, the DEP determines if disinfection is required on a case-by-case basis.

Subsurface effluent disposal

The utility of a SSWTP is only as good as the availability of a disposal area for the final effluent. The effectiveness of disposal is constrained by the ground water, bedrock, permeability of soils, and the quantity of effluent proposed. Hence, subsurface disposal is extremely site-specific. The means of effluent disposal are all relatively similar and attempt to evenly spread the fluids into the ground. Typical systems use open sand beds, leaching pits, leaching chambers, or leaching trenches.

Subsurface effluent disposal in Massachusetts is strictly governed by the DEP. There are many conservative guidelines, any one of which can prevent the licensing of the treatment facility. For example, the bottom of a sand bed including any mounding must be greater than four feet above the maximum ground water elevation. Additional guidelines include that a tested reserve disposal area is available and capable of replacing the original leaching area.

Sludge disposal

The processing of residual sludge and scum is complex and due to concerns about odors it is usually not done at SSWTP sites. Instead, wastes are periodically collected and transported to a specifically designed operation. Current disposal methods include landfilling, incineration, land application, and composting.

Operation and Maintenance

The lack of proper operation and maintenance of SSWTPs can result in extremely variable levels of wastewater treatment and a failure to meet permit standards. Therefore, a wide range of guidelines and strict regulations exist in Massachusetts, to ensure for continuous uninterrupted sewage treatment. Included are guarantees of financial accountability, sludge handling, and operator and personnel responsibilities.

Massachusetts regulations require that all permitted sewage treatment facilities must be operated by a certified wastewater treatment plant operator (257 CMR 2.00). In the event of an emergency, a certified operator or assistant, is required to be on call 24 hours a day, seven days a week. The recommended amount of operator time actually at the facility varies depending on the source. State guidelines require that a certified operator spend a minimum of two hours per day, five days a week and additional time as conditions warrant. The Massachusetts Association of Health Boards, Inc. recommends a minimum of three hours each day and at least one hour a day on weekends and holidays. However, an operator of several SSWTPs in Massachusetts reports that if everything is working properly, not even fifteen minutes per day at each facility is needed (Dobie, 1988).

Failures and Reliability

The general reliability and the risk of a system failure of a SSWTP continues to be of great concern regarding their current use and proliferation in Massachusetts. References are continuously made to the circumstances involving a failing POWTF in Rhode Island which discharges raw sewage into the Sakkonet River. The system was built to serve a 30 house subdivision in Portsmouth in the mid-1960s because the site would not enable the use of individual septic systems. Proper maintenance was not exercised and poor siting of the system led to a complete failure which arose in the 1970s and still exists today. Rhode Island no longer allows the use of POWTFs and is still trying to determine liability for the resultant pollution to the Sakonnet River.

To avoid the problems encountered in Rhode Island the DEP has included many safety features into the design guidelines which must be met prior to receiving a groundwater discharge permit. The recently published Generic Environmental Impact Report (MEOEA, 1990) on SSWTPs extensively analyzed these guidelines, and concluded that they represent a conservative approach which is both effective and workable (MEOEA, 1990). However, system malfunctions and failures have occurred at facilities throughout the State. Based on the favorable report in the GEIR, these occurrences are apparently considered to be at an acceptable level.

There are a wide range of potential problems which can affect the operation of SSWTPs. The problems with subsurface disposal have been discussed previously, and the next section is limited to malfunctions and failures within the treatment plant.

Treatment plant failures

Most of the processes within a SSWTP require electrical and mechanical devices which are susceptible to malfunctions. Continuous high humidity aids in the corrosion of parts and around the clock operation act to reduce their durability. Critical parts which break down can lead to little or no treatment of wastes, while less important ones may only cause slight changes in water quality effluent. Either way, the potential for violating the permitted limits of effluent quality always exist.

In the almost 15 years of use of RBC systems in Massachusetts, there have been only three mechanical breakdowns which the DEP did not consider "..routine replacement.." of parts (McGregor et. al., Public Comments, 1987). Two occurrences involved large municipal plants, and one was privately owned. Two of these breakdowns were experienced during their start up phase, and were attributed to manufacturer/installation errors. Each of these facilities operated during repairs and continued to function without a permit violation. However, the third facility was taken out of service for approximately three months before repairs were completed. During that time, the effluent quality deteriorated beyond legally acceptable levels.

There are many other cases of system failures at SSWTPs deemed by the DEP as relatively minor and routine. These problems are attributed to normal usage, and are typically due to clogged filters, broken pumps, belts, and other quickly repairable parts. Even though minor problems can lead to permit violations, the DEP appears to accept the fact they will periodically happen. In support of the proposed technology for the Willis Hill Development, they remarked that "..minor failures are endemic to any mechanical system..." (MEOEA, 1988). The DEP does, however, require that an inventory of high wear components such as belts and chains be kept at treatment facilities.

Compliance with Groundwater Discharge Regulations

The compliance records of existing POWTFs in Massachusetts can be used to get an indication of what could be expected if in the future they are allowed for residential subdivisions. These data are, however, of only limited value because of continuous technological improvements, and their short history of use in the State. Most of the long-term data available are for plant designs which are no longer being proposed for new development. New plant designs and the recent updating of state regulations will presumably lead to more reliable operations than have existed in the past.

Two surveys were found which evaluated groundwater discharge permits and compliance of POWTFs. Both utilized DEP data collected between 1984 and 1987. One review, prepared by the DEP, simply states that out of 28 POWTFs assessed, there was an overall compliance rate of just over 97 percent for BOD and 98 percent for total suspended solids (TSS) (MEOEA, 1990). Though it was not explained how these figures were derived, it was pointed out that all non-compliance occurred within the first six months of operation. The DEP data infers that once a system has had enough time to become regular its compliance problems will not exist.

The second survey presented extensive data, which focused on more variables including peak flow, coliform bacteria, ph, BOD, and TSS (Young, 1990) (See Table 11).

TABLE 11

SSWTP NON-COMPLIANCE BY PLANT TYPE AND DEVELOPMENT

(percent)

	BOD	TSS	Flow	Coli-form	NH3* 10	NH3* 30	NO3* 10	NO3* 30
All Plants	8.3	5.5	8.4	13.6	33.3	2.3	37.4	1.4
All RBCs	6.3	4.9	4.2	0.0	33.2	2.2	41.6	2.0
Condominiums	5.9	6.0	3.2	0.0	35.8	2.0	32.2	1.1
Other	7.5	1.5	8.3	0.0	25.4	3.0	67.2	4.5
All Activated Sludge	11.1	6.3	14.0	21.9	33.3	2.5	31.7	0.5
Condominiums	16.0	7.4	0.0	35.0	14.3	1.1	13.0	0.0
Other	6.3	5.3	25.0	0.0	57.7	4.2	50.0	1.1
All Condo.	9.1	6.5	2.2	20.3	29.1	1.7	25.8	0.7
All Other	6.8	3.7	19.6	0.0	42.0	3.6	57.1	2.5

* 10 (mg-N/L) and 30 (mg-N/L) were not specified permit limits. They are standards assumed for the sake of the analysis only.

Source: Young, C., Master Thesis, Tufts Universtiy, 1990.

The data were collected from 19 POWTFs, nine of which were RBCs and chosen intentionally because they are the type most often proposed for new residential developments. Information used in this survey was based on the amount of time that each treatment plant was in non-compliance with State thresholds for the parameters. Values in Table 11 represent monthly averages of non-compliance. Data sets for individual plants varied between 2 and 52, and were taken between 1984 and 1989. Overall, the compliance rates for RBC plants were higher than for the activated sludge method of treatment, possibly because these facilities were generally newer (Young, 1990). These results, whether or not statistical valid, clearly exhibit compliance levels much less than those presented by the DEP.

Septic System Technology Compared with SSWTPs

There are many studies which have compared the effluent quality of septic systems to more advanced systems such as those used at SSWTPs (USEPA, 1977; 1978; and 1979). In all cases, similar results were noted prior to subsurface disposal. When properly operated and maintained, advanced treatment provides better effluent quality than conventional septic systems.

Provided below is a table which has been used in many publications involved with the controversy of permitting SSWTPs in Massachusetts for residential subdivisions (See Table 12). The Table shows the difference in effluent

TABLE 12

SEPTIC TANK EFFLUENT VS. ADVANCED WASTEWATER TREATMENT FACILITY EFFLUENT CHARACTERISTICS [1]

Parameter	Influent Quality [2]	Effluent Quality [2] Septic Tank	WWTF [3]
BOD 5	300.0	170.00	15
Total Suspended solids	300.0	60.00	<10
Total Nitrogen	45.0	42.00	<10
Ammonia-Nitrogen	12.0	40.00	<2
Nitrate-Nitrogen	0.6	0.04	<10
Total Phosphorus	25.0	14.00	10
Fecal Coliform	30,000.0 coliform/100ml	5,000,000.00 coliform/100ml	<100 coliform/100ml

1 Measured prior to land application
2 All values in mg/l except as noted
3 Secondary treatment followed by denitrification and disinfection

Sources:

Canter, L.W. and Robert C. Knox. Septic Tank Systems Effects on Ground Water Quality Lewis Publishers, Inc., Chelsea, Michigan 1985

Massachusetts Division of Water Pollution Control Data

USEPA, Alternative for Small Wastewater Treatment Systems, EPA - 625/4-77-011, 1977.

quality of these two generic treatment systems. It was compiled by the Massachusetts DEP Division of Water Pollution Control in their response to public comments for a groundwater discharge permits for the proposed Willis Hills Housing Development in Sudbury, Massachusetts. It clearly shows that SSWTPs have the potential to discharge high quality effluent, far greater than septic systems.

These data alone, however, are not adequate to evaluate all the environmental risks of either system. Mechanical failures, improper maintenance, and poor soil conditions must also be evaluated when comparing alternative treatment systems. For example, if for any reason a SSWTP is not operating correctly, it can lead to improper treatment for all users connected to the facility. On the other hand, the failure of only one septic system represents only a portion of a housing development. This situation points out that treatment plants may be a proven technology, but the overall risks are much higher than with conventional septic systems.

Use of POWTPs in Massachusetts

In Massachusetts, POWTFs have been used for over fifteen years to treat wastewater. There are currently over 150 permitted facilities being used to treat sanitary, industrial and recovery wastes throughout the State (MDEQE, 1988a). Approximately 70 of these treat sanitary wastes at condominium complexes, companies and schools, all which are owned by single entities.

Recently, there has been a increase in the number of applications for groundwater discharge permits for POWTFs. Of a total of about 49 applications, 13 have been for residential subdivisions. The State has yet to permit them for such a use because of financial liability. If allowed for residential subdivisions, probably many more applications would be submitted.

Land-Use Implications of POWTPs

The land-use implications of POWTPs have created some of the greatest concern among those examining their impacts throughout Massachusetts. Municipal officials are concerned that if allowed for subdivisions, the use of this innovative technology could affect the intent of many existing land use regulations, thus affecting long-term planning goals. The intent of out dated zoning and subsurface wastewater disposal regulations in particular are the most susceptible with the application of POWTPs. Not until recently, and then only on a limited basis, has any research investigated the land-use impacts of POWTPs.

Title V Use for Growth Control

The Massachusetts Environmental Code (Title V) was promulgated in 1966 in order..

"..to provide minimum standards for the protection of public health and the environment when circumstances require the use of individual systems for sanitary sewage in areas where municipal sewers are not accessible" (310 CMR 15.00).

The regulations within Title V focus upon the physical characteristics of property that are required for an individual sewage disposal system (ISDS) to function properly. It also lists the materials needed for construction of the system such as piping, distribution box and septic tank. For the use of ISDS, the Title V regulations are a strong regulatory measure that utilizes conservative criteria. Incorporated towns are granted the power to enact more stringent regulations than those under Title V, when local identifiable conditions exist (310. CMR 15.00).

There is no reference in any of the Title V regulations indicating that they were designed to be used as a mechanism for restricting land-use for development. However, due to the nature of these regulations, they have indirectly, as well as intentionally been applied by municipalities to provide a form of growth control. It limits development to only those parcels which meet the criteria for ISDS. Many areas are zoned with no expectation of that zoning density ever being reached. Areas with shallow bedrock, a high water table, and other conditions which would not meet the conditions of Title V, are considered protected, and until now, needed no further protection to remain relatively undeveloped.

A survey completed for the GEIR of 14 Massachusetts communities found all but one which indicated that Title V and local board of health regulations acted as a major deterrent to land development (MEOEA, 1990). Part of the reason for this situation is that adopting zoning bylaws to restrict development can be a very difficult and lengthy process. It requires town meetings and city council votes. Adopting board of health and Title V regulations does not require nearly as much public and political support.

POWTFs now threaten to undermine many communities' development and open space plans, if they allowed for residential subdivisions, because they relied on Title V restrictions instead of executing proper zoning and land use planning (MEOEA, 1987). Large areas of land not suitable for ISDS may now be susceptible to development with the use of POWTFs. Technological advances in wastewater treatment and a booming economic situation in the region during the 1980s made their use viable practically overnight for residential subdivisions. This threatening situation, posed at many municipal planning departments, is illustrated in a letter to the members of the Citizens Advisory Committee for the GEIR.

"...the old game of restrictively applying Title V as a means to restrict growth may be over given advances in technology represented by packaged treatment plants." (Kuehn and Engler, 1989 p.1).

In a similar statement, the president of the Massachusetts Association of Health Boards considered the application of POWTFs to pose...

"... a greater threat and challenge to the orderly and properly development of our Commonwealth than perhaps any other regulatory interpretation in the past 20 years" (Benes, 1987, p. 91).

The reasons why POWTFs are able to overcome many of the technical limitations of Title V, which would otherwise prevent the large developments using ISDSs, is rather simple. Since the effluent undergoes extensive treatment prior to entering the soil, it requires a relatively small area for leaching compared the the cumulative area of individual leaching areas for each house if ISDS were otherwise utilized. Similar to a septic system leaching field, it is still imperative to situate them where the soil conditions are suitable. Unlike a ISDS, however, a leaching field is not required for each individual dwelling, therefore, houses tied into a POWTF can be built on parcels which otherwise would not pass the criteria of

Title V. An additional way in which a treatment facility can overcome the development restrictions poised by Title V is by avoiding many of the setback distances which subsurface disposal areas must comply with. For example, many of the setback distances for dwelling structures, wetlands, water supplies, and subsurface pipes are not as strict as the distance for a septic system leaching field.

POWTFs Impact on Land-Use and City Planning

One of the greatest controversies involving the use of POWTFs for residential subdivisions is their potential impacts on land-use and city planning. Practically all non-profit environmental organizations, municipal boards of health, as well as state planning and environmental agencies have expressed concern that they may lead to rampant development, where it would have otherwise not have occurred. Conversely developers are acclaiming their use for both offering the capability for advanced sewerage treatment in rural areas, and supplying a viable technique for preserving open space. Actual data to support either argument are limited because only one subdivision has actually been built utilizing the technology. Although there have been many proposals, none have been finalized or permitted. Therefore, the potential statewide land use affects can only be estimated. The problem facing city planners is that many of the existing regulations and development forecasting were based on the use of traditional septic systems, and did not attempt to include the unknown impacts posed by POWTFs.

The use of POWTFs can allow for more flexible land development on properties which make it difficult to cluster single family home developments with septic systems. By overcoming some of the Title V and municipal board of health regulations, developers and planners can bolster open space preservation by permitting clustered development. Confining a limited amount of the development to only a portion of a property can allow for the adjacent areas to remain undeveloped. This concept is agreed upon by several Massachusetts Regional Planning Officials, but only when the facilities are used in conjunction with the appropriate cluster and planned unit development bylaws (MEOEA,1990). Even though the advocates of POWTFs often cite their potential for preserving open space, so far only two proposals presently under consideration include clustered development that would result in significant amounts of preserved open space (Burrington, 1988).

The opposing view of POWTFs with regards to their impact on land-use and city planning is supported by practically every non-profit environmental organization in the State. Only vaguely, if at all, do environmentalists advocate any of the positive uses of this technology. Their newsletters, testimonies, and research have all been oriented towards alerting the public of any adverse impacts which these facilities may pose to the environment.

Included in almost all their media are references to the impact that POWTFs will have on allowing development on property which was previously thought to be undevelopable. They focus on the fact that under the present regulatory controls POWTPs can be used to place development on the edge of sensitive environmental areas by locating the treatment plant in a more suitable area. For example in a testimony to approve legislation imposing a temporary moratorium on POWTFs, Dan Greenbaum, Vice President of the Massachusetts Audubon Society said:

> "These plants will also open up thousands of acres for development which cities and towns had thought would never be developed, and the communities have barely had time to catch up with the onslaught" (Greenbaum, 1988).

Illustrating the land use impacts of POWTFs is difficult because only one has been permitted and built for a residential subdivision in Massachusetts. This development, in Ipswich, is however unique in that with the purchase of each housing unit the owner also obtains title to partial ownership of the adjacent full 18-hole golf course. Although this subdivision did lead to extensive tracts of open space, it cannot be considered a typical development. What must also be evaluated are the numerous proposals which have been submitted throughout the State. These proposals display a combination of both clustered as well as even dispersal of development throughout a development area. The one aspect that they all have in common is that virtually all would allow for more development than would exist under Title V septic system constraints, even if the development did utilize a clustered pattern (Burrington et. al., 1989).

A development in Middleborough, proposing to use a POWTF, is indicative of clustered development which would not lead to any additional open space. This proposal is for a 700-unit mobile home community to be built on a 875-acre site. All construction is slated to occur on just 350 acres of the property leaving the other 525 acres to remain undeveloped. Only a superficial viewpoint of the project would lead one to believe it appear that a large tract of land is preserved due to the utilization of a POWTF. However, further review finds that the undeveloped portion consists entirely of wetlands. Within the Environmental Impact Report (EIR) is information indicating that the project would not be viable without the use of a POWTF. Even in the woodland areas only a few sites were found to have acceptable percolation rates (Burington and Rockefellar, 1988). In this particular instance, the use of the POWTF would directly lead to the development of a large tract of land.

Although the State is responsible for much of the permitting of POWTFs, the impacts of additional growth will be primarily upon the individual municipalities. Each municipality, however, varies in its capability to assess and plan for the impacts of increased residential development. Only about 40 percent of the State's 351 incorporated cities and towns has either a full or part-time planner. Almost all others rely on a volunteer planning board, which often lacks technical expertise and the time needed to adopt proper growth management strategies to minimize negative impacts of POWTFs (MEOEA, 1990).

There appears to be a consensus in Massachusetts that local cities and towns are not prepared to deal with the possible land-use impacts from POWTFs. In a letter to the MDEQE, Marcia Benes (August 26, 1987), the MAHB president, stressed that due to the suddenness of the numerous proposals to utilize POWTFs, the affects on town planning "could be disastrous." Likewise the City Planner of Marshfield testified that even without the use of POWTFs, the ability of many cities and towns to meet the required growth services is already at a shortfall, and their use would be a "grievous complication of already stunning changes" (Almada, 1987). These towns and others are concerned that they could effectively lose what control they now posses over future development. Most municipal zoning and master plans were designed with Title V and local board of health regulations in mind, and include little planning for property which was considered only marginally acceptable for ISDSs. Because POWTFs are a technologically viable alternative for ISDSs, municipalities are being forced to quickly evaluate options for growth control measures or adhere to their existing regulations which may allow for subdivisions utilizing POWTFs when all other criteria met.

Due to the increasing number of residential subdivisions proposing POWTFs and the uproar from environmental groups, state and local governments were forced to begin the process of formulating new regulations and policies before precedent setting developments were built. The State's first response began in 1987 by beginning to update the DEQE design guidelines for SSWTPs, which was originally released in 1975. The updated version was needed due to advances in water pollution control technology, as well as, incorporating a more detailed scope of the planning and approval process.

During this same time period, the State was compelled to make its first permit decision for POWTF use in a residential subdivision at the Willis Hills Development, in Sudbury. Knowing this was to be a precedent setting decision, there were extensive testimonies both on behalf of opposition groups and advocates for the development. The permit was finally denied on April 19, 1988, mainly due to financial liability of the treatment facility, but also due to:

"foreseeable, but yet unexamined environmental impacts...particularly on parcels of land previously not capable of being developed in accordance with Title V standards" (MEOEA April 19, 1988, p. 6)

In the denial, the State concluded that there was a larger land-use policy issue (involving the increased development potential) which required resolution, but was not the responsibility of the private developer. The vast array of unanswered statewide problems which became apparent from the Willis Hills decision lead directly to the Secretary of Environmental Affairs declaring that a GEIR would be written to address the technological, legal and planning issues related to SSWTPs.

The results of the GEIR were in accordance with many of the original concerns of city planners, environmental organizations, and concerned citizens. Development intensity and location is expected to be altered, but to what extent these impacts will occur is still not known. When used in combination with the proper municipal regulations, POWTFs can be used to facilitate creative development. The problem lies in that most municipalities do not have the adequate zoning and master plans to ensure that development follows in an orderly and desired fashion.

Potential Land Development from POWTFs

Effective long-range planning for any community relies on evaluating the legal and physical constraints to its developability. The extent that its land can be developed must be clearly established, in order to understand and plan for the possible impacts on natural resources, municipal services, and aesthetic quality. As previously described, many unsewered communities throughout the state have inappropriately based their development plans on septic system suitability. Therefore, when estimating their potential future development and population densities they have inaccurately failed to include marginal properties which may now be developable with the use of POWTFs.

Build-out studies are a valuable method used to assess the maximum potential for development under an existing framework of local land regulations and physical conditions. Many towns have calculated their potential build-out based solely on septic systems and only recently has there been any attempt to assess the added development potential of POWTFs. An estimate, by city officials in Sudbury, has indicated that increased development from this technology could be as high as eight percent (Kirby, 1987). Similarly, lands which do not pass a perc test for a septic system have been estimated at 10 percent and 50 percent for the Towns of Acton and Sterling, respectively (Young, 1989). Only two thorough build-outs in

Massachusetts, in the communities of Hopkington and Lanesboro, have been completed which focused specifically on the impacts of POWTFs. Below is a synopsis of the results from these two studies.

Hopkington build-out

The Hopkington build-out study was conducted by the MAPC, as part of the GEIR to compare the maximum potential development under Title V of the State Environmental Code with the development possible under current zoning using POWTFs (MAPC, 1988a). Hopkington was chosen, in part because at the time it had five proposals to utilize POWTFs, and overall it was in the center of an area receiving heavy development pressure (Municipal Impact, 1988). It was generally believed that the study would show a significant potential increase of development in non-sewered areas. The results were unexpected, and indicated that community-wide the growth impacts would be only minor, but on individual parcels the results were significant.

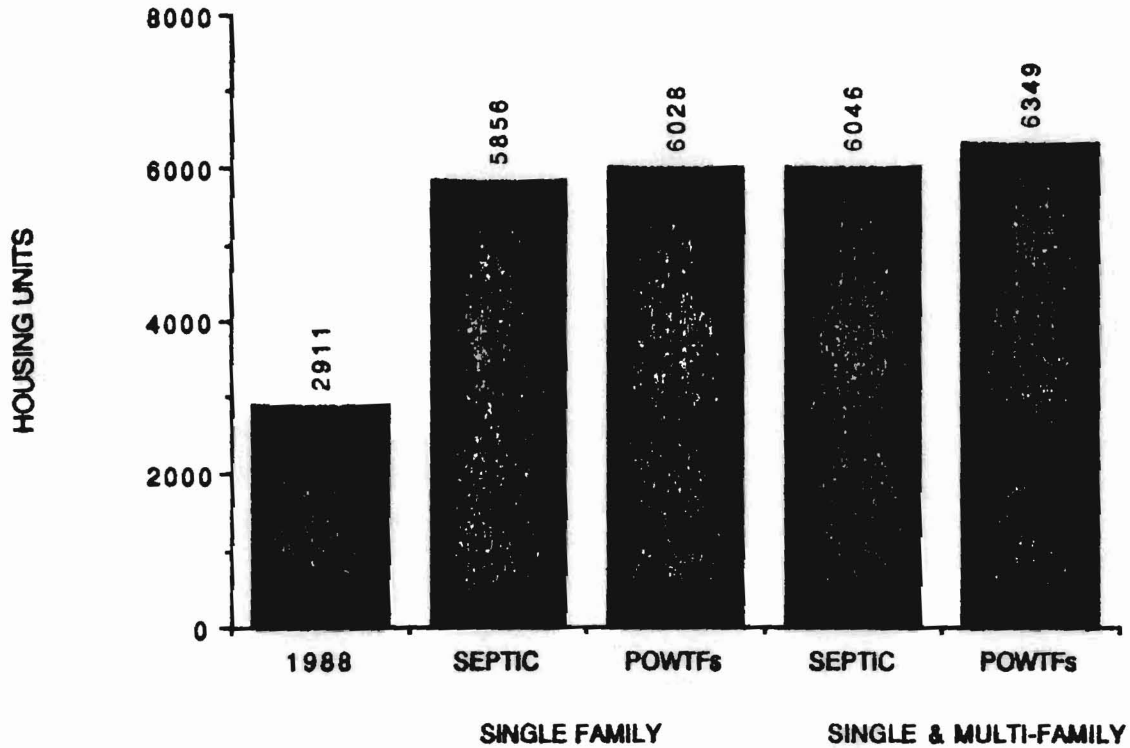
The methodology of the Hopkington study depended on many assumptions concerning the size of development, wetland buffers, soil limitations, and minimum parcel and treatment plant sizes. Each of the variables were further constrained by considering the pertinent state regulations involving Title V, the Wetlands Protection Act, and local zoning districts. Basing the study on the smallest economically viable treatment plant of 15,000 gpd, a minimum parcel size of 20 acres was established. This is the smallest area possible to accommodate 45 single family detached homes. It was assumed that this number would cover the cost of the facility. Assuming that adjacent properties would not be combined, a total of 130 undeveloped parcels were identified, ranging from 20 to 183 acres.

Using Soil Conservation Service (SCS) maps, each parcel was analyzed for environmental constraints in relation to Title V and the Wetlands Protection Act. The SCS maps include localized developability. Information collected included slope, depth to seasonal high water, depth to bedrock, permeability, and depth of pervious material. Each variable had an acceptable range for residential and septic system use. Even though SCS information is not intended for individual parcel assessment it is adequate as a large-scale planning tool. Since septic systems are not allowed within 100 feet of delineated wetlands, these areas too were subtracted from each parcel. When the local zoning restrictions were combined with the limitations from environmental constraints, only 12 parcels in the town were found acceptable to allow development with POWTFs.

The final build-out showed that the town has the potential to more than double its existing housing supply of 2,911 units using septic systems alone for single family homes (See Figure 9). A total of 5,856 housing units could be reached, an increase of 2,945 housing units. With the

FIGURE 9

HOPKINGTON BUILD-OUT RESULTS



Source: Metropolitan Area Planning Council, 1988.

use of POWTFs, the total possible number of single family houses reaches 6,028, an increase of of about six percent. If multi-family housing is developed on the four parcels which are suitable for POWTFs, but can not meet the minimum of 45 single-family homes, the potential increase between the two scenarios reaches nine percent. Even though the town-wide potential may not be as great as some people may have thought, on individual parcels the growth potential comparison is significant (Table 13).

The results of this study show that POWTFs do allow for the possibility of increased development compared to septic system use. They do not give any direct reference to open space, but it can be assumed that a corresponding decrease in open space will result. Even though the study focused on actual development, it can be assumed that a corresponding decrease in open space would result from the increased development. This study generated precise numbers of housing units, however, the count must be approached with caution, because it is based on so many assumptions. Should POWTFs be used in the future, the development scenario could end up being rather different. A full critique of these and other analogous assumptions will be made on the build out scenario of Gloucester.

Lanesborough build-out

The Lanesborough build-out was a similar analysis to the one conducted for the town of Hopkington (Clark

TABLE 13

HOPKINGTON BUILD-OUT RESULTS

Residential Type	# Units With Septic	# Units With POWTFs	Difference	Percent Increase
Single family	751	923	172	23
Multi-family	190	321	131	68
Total	941	1244	303	32

Source: MAPC, Hopkington Build-Out Analysis: Impacts of Privately Owned Sewage Treatment Facilities, June, 1988a.

Engineering, 1989). Only a portion of the town was evaluated and a few other changes were made in the methodology, including a greater incorporation of local conditions and regulations. Existing soil percolation data and test holes were used to supplement the SCS information, in an effort to more closely depict the existing conditions. The Lanesborough Board of Health Regulations, which are stricter that Title V, were also used. A significant difference from the Hopkington study is that the analysis did not restrict the size of the treatment plant to 15,000 gpd. It was assumed instead, that a 10,000 gpd treatment plant was economically viable in Lanesborough.

Unlike the Hopkington build-out, the results indicated that POWTFs could have a major effect on the development potential in the region of Lanesborough (See Table 14). Four parcels met the minimum criteria for a treatment plant, representing a potential increase of 50 percent in single family housing. More significant were the results based on the use of multi-family apartments, where possible, under local regulations. Under this scenario, an additional 1,070 apartment units could be developed with the use of treatment plants. Unlike the results from the Hopkington build-out, these figures are based on all the property within the study area, not just a comparison of the build-outs in areas meeting the criteria for POWTFs.

TABLE 14

LANESBOROUGH BUILD-OUT RESULTS

Residential Type	# Units With Septic Only	# Units With POWTFs & Septic	Difference	Percent Increase
Single Family	162	243	81	50%
Multi-family apts	329	1399	1070	325%
Total Difference			1151 units	

Source: Clark Engineering, 1989.

While the study shows that technically the potential exists for massive amounts of development in Lanesborough, the reality of it ever happening is unknown. Market conditions play an important role, especially in an area which is not under heavy development pressure such as that found in the western part of the State. However, the study did exemplify a situation which could exist in other regions. As previously described, development resulting from the use of POWTFs is determined by financial viability, local conditions and regulations, which will often be radically different from one town to another. Both the Hopkington and Lanesborough studies are valuable for comparisons with other studies to be conducted under different local conditions.

CHAPTER V

PROFILE OF GLOUCESTER

Location and Size

Gloucester is part of Essex County, located in the northeastern part of Massachusetts (see Figure 10). Bordered by the towns of Rockport, Manchester, and Essex it extends out into the Atlantic Ocean creating the peninsula named Cape Anne. With Ipswich Bay to the North and Massachusetts Bay to the South, Cape Anne is a prominent feature of the Massachusetts coast.

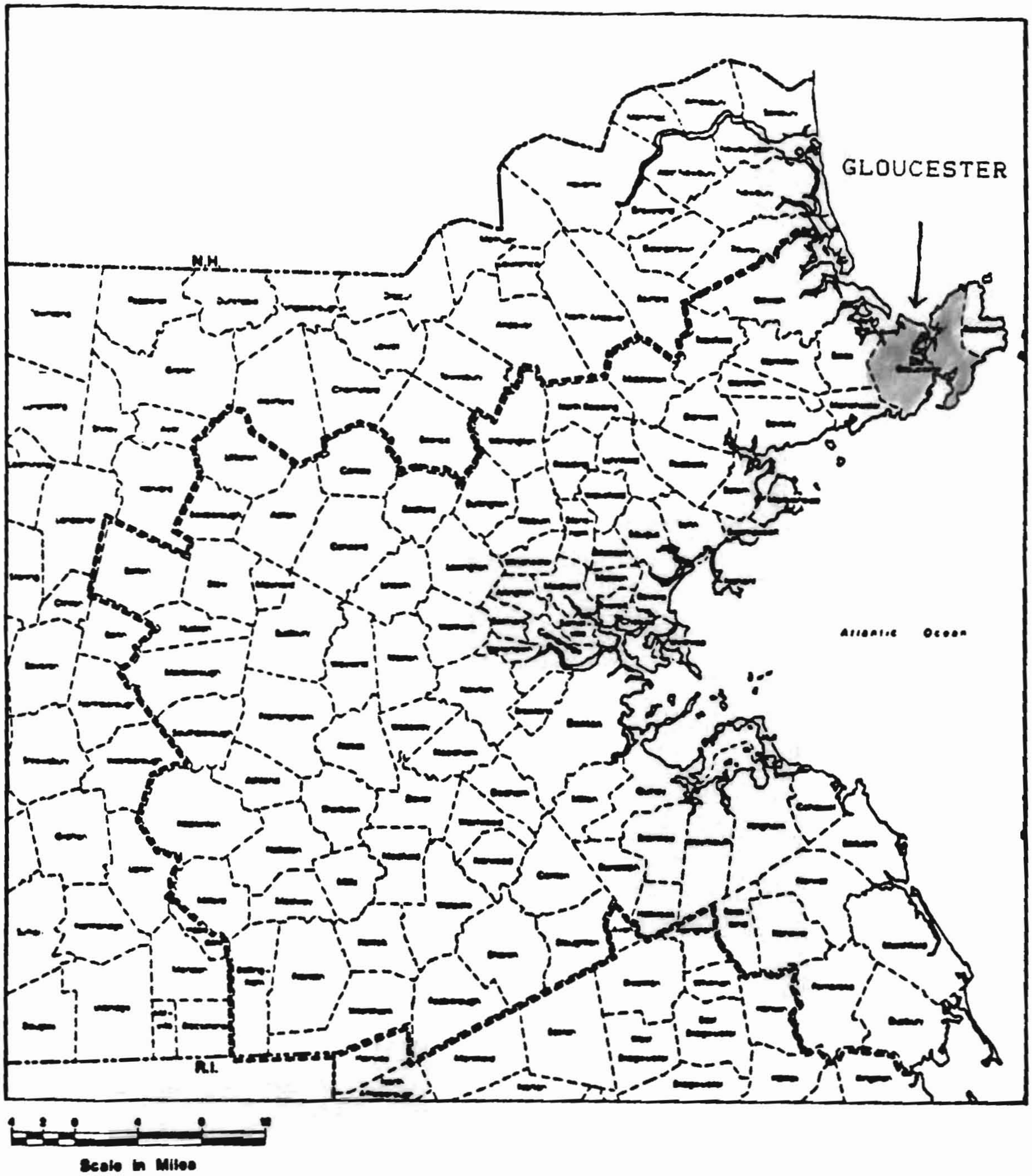
Gloucester is a moderately sized city ranking 113 in statewide municipal and town area, encompassing a total of 26.18 square miles (Gloucester Open Space and Rec. Plan., 1990). However, Gloucester has over 64 miles of undulating shoreline which makes it appear much larger (See Figure 11). The shoreline follows numerous inlets, coves, and creeks. The Annisquam River divides the city and the large main harbor encompasses over two square miles.

Landscape and Natural Features

Gloucester has a wide variety of topographical and natural features which have acted to impede commercial and

FIGURE 10

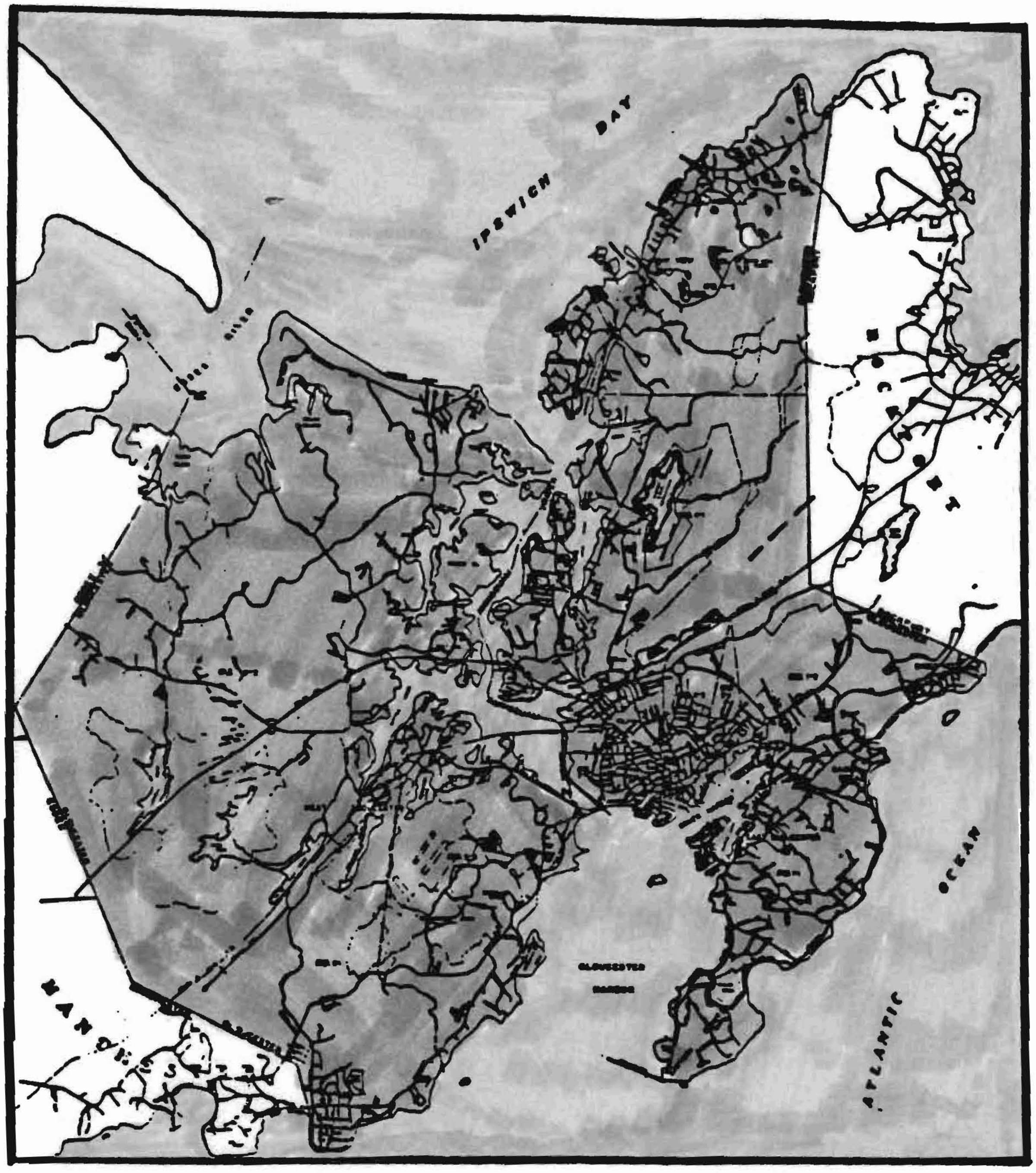
LOCATION MAP OF GLOUCESTER



Source: Metropolitan Area Planning Council, 1992.

FIGURE 11

SPECIFIC MAP OF GLOUCESTER



residential development in many parts of the city. A thick layer of granite bedrock dictates the general geography of the region. Stony loam and rock outcroppings make up a large part of all surface soils. Elevations range from sea level to about 270 feet. Geomorphology and the effects of the large granite industry in the 1800s have created a topography characterized by exposed ledge, surface boulders and steep slopes. There are virtually countless locations, mostly in the northern part of Gloucester, where visible granite mining activities have taken place and altered the landscape. These include large quarries with vertical profiles over 100 feet in height.

Surface waters, watersheds and wetlands are also an important feature of Gloucester's environment. Seven of the larger water bodies, and their surrounding watersheds are part of the resovoir system supplying freshwater throughout the city. Approximately 22 percent of the entire land area of Gloucester is associated with these watersheds (Gloucester Open Space and Rec. Plan, 1990). Within these watersheds are large areas of wetlands, which are both physically difficult as well as legally prohibitive to development. By virtue of their relative permanency, they act as valuable areas for wildlife habitat and other amenities associated with permanent open space.

The combination of soils, wetlands, and varied topography has facilitated a wide diversity of ecological niches in Gloucester. Vegetation types vary with oak being the predominant tree species; stands of beech, white birch, willow and red maple are also locally common (Gloucester Open Space and Recreation Plan, 1990). Animal species such as squirrels, chipmunks, opposums, muskrats, fox, and a wide variety of birds are also locally abundant.

Coastal Resources

Gloucester's proximity and its relationship to the ocean are considered to be its greatest natural resources. The marine environment is the setting for most of Gloucester's commerce, tourist attractions, and population centers. Demand is high for all available shoreline property. As coastal populations rise, the coastal environment is increasingly receiving stress from urban runoff, loss of habitat, and malfunctioning sewer and septic systems.

The coastal and near-coastal environment of Gloucester is one of exceptional beauty. The nearly 64 miles of shoreline is made up of coastal and barrier beaches, salt marshes, and the rocky shore. There are fourteen beaches encompassing a total area of over 200 acres (Gloucester Open Space and Rec. Plan, 1990), and just over 1,100 acres of salt marsh (MAPC, 1988c). These areas provide both recreational and visual resources attracting thousands of people on any sunny summer day.

The water quality surrounding Gloucester is variable. All regions other than Gloucester harbor are classified as a Division of Water Quality Control rating of "SA", the highest classification possible (314 CMR 4.05). Designated uses for "SA" waters includes marine fisheries, shellfishing, and recreation. However, many of Gloucester's shellfish beds in "SA" waters are periodically closed to shellfishing due to high levels of coliform bacteria presumably from malfunctioning sewer and septic systems. This has become an increasing problem in recent years with up to 40 percent of all shellfish beds closed or restricted at any given time (Britcha, 1988). Shellfish bed closures are much more than just an environmental problem; they cause loss of revenues to shellfisherman and related businesses. It was estimated that lost income due to closed shellfish beds cost the community approximately $332,400 in 1980 (Hruby, 1981).

Inventory of Land-Use

First settled in 1623, Gloucester has a long history of development and land-use changes. General land-use surveys have been conducted and compiled for the City in 1971, and as recently as 1985 (MacConnel, 1987; and 1988). Site specific information on open space is available from the City's 1990 Open Space and Recreation Plan. Aided by these two documents, it is possible to develop a clear picture of present land use throughout Gloucester. In general, there exists a wide variety of commercial, industrial and residential development along with many areas of undisturbed woodlands.

Geographic variables, such as the large deep water harbor and the Annisquam River, have played an important role in the location of much of Gloucester's development. As with most coastal communities, commercial and industrial development is concentrated around the harbor region, with marine-related businesses predominating the shoreline. Located adjacent to the western shore of the inner harbor and extending to the Annisquam River is the City's central business district of commercial enterprises, public offices, restaurants, and many small parking areas. Representing a total of only about one percent of the City's entire land area, most commercial and industrial development is located around the harbor region. A few other relatively small central business districts are located outside the harbor region but are also in close proximity to the shoreline. Other than three small industrial parks, the inland regions of Gloucester are relatively free from both commercial and industrial development, and only recently has there been any large efforts at developing these areas for residential purposes.

Residential development encompasses about 23 percent of the land area of Gloucester (Table 15). The harbor region is heavily developed with multi-family and dense residential development. Other surrounding regions of

TABLE 15

GLOUCESTER LAND USE AND CHANGES

		Acres 1985	1971	% Change
URBAN	Industrial	175	105	67
	Commercial	157	151	4
	Residential			
	multi-family	42	27	57
	dense	678	678	0
	medium	1795	1746	3
	light	1352	1206	12
	Transportation	269	269	0
	Open and Public	296	228	30
	Urban Total	4765	4410	8
AGRICULTURE		116	116	0
OPEN LANDS		557	606	-8
FOREST		9690	9960	-3
RECREATION		280	267	5
WETLANDS		1641	1660	-1
MINING		13	60	-78
WASTE DISPOSAL		84	88	-5
COMMUNITY TOTAL		17146	17167	

Source: MacConnell, William, Department of Forestry and Wildlife Management, University of MA., Amherst 1988.

Gloucester are mostly light and medium density residential areas. These areas represent over 80 percent of all land devoted to residential use, and are focused around the smaller central business districts.

Open Space and Protected Lands

Gloucester has a relatively large proportion of property which is undeveloped. Approximately 70 percent of the municipal area or about 11,600 acres, is presently undeveloped. These parcels are, however, affected by a wide range of ownership and regulations, rendering some as permanently protected open space, and others as prime land open for development. Only about 4,900 acres throughout the City has any reasonable protection as open space. These areas consist of land owned by local land trusts, fresh and salt marsh, watersheds, and city owned-land.

Recent Development

Residential development pressure in Gloucester had been heavy throughout the late 1980s. In addition to the high demand to live in Gloucester, sewer extensions, a booming economy, and improved methods for developing marginal land all contributed to increased development. Proposals for single house lots, condominiums, and large subdivisions emerged for every region of Gloucester, where there existed undeveloped property.

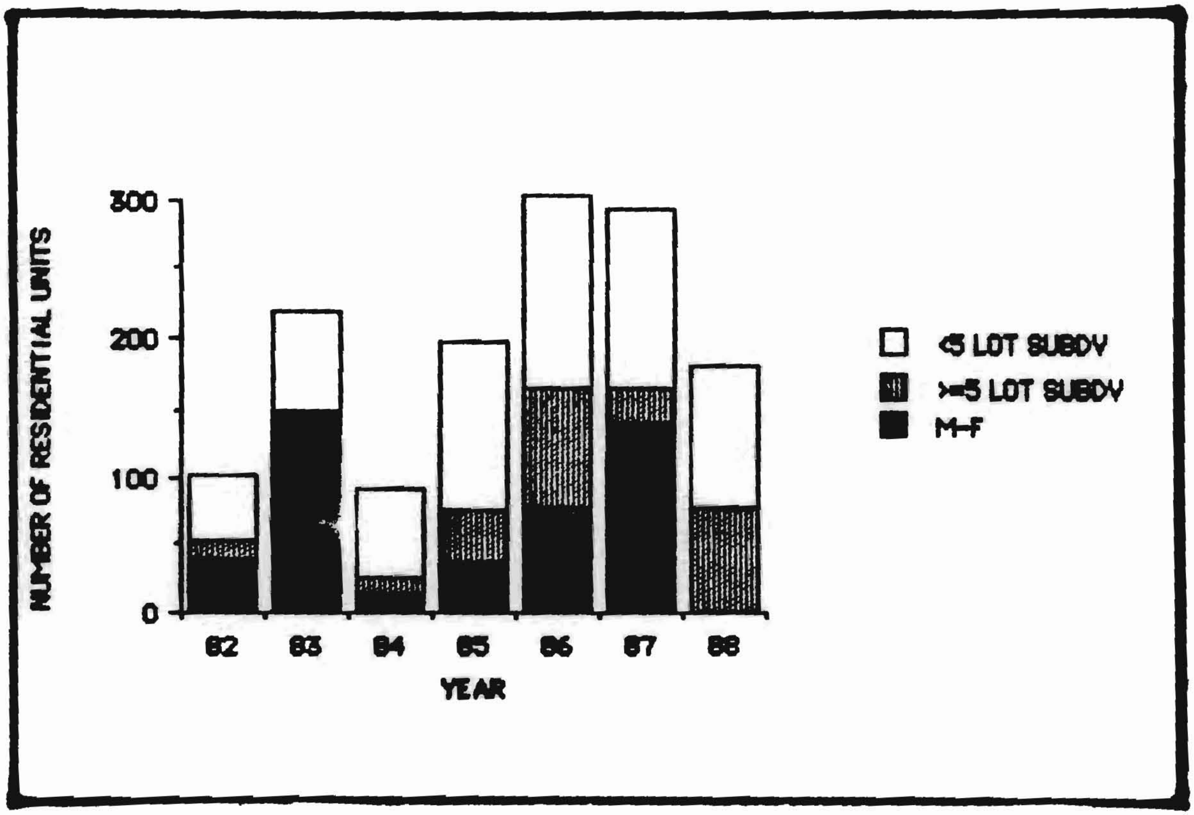
Since 1950, the yearly average number of new housing units has increased by only about 120 per year (Gloucester Master Plan, 1990). A significant increase is, however, evident for the years 1985, 1986, 1987 and 1988, when the number of actual and approved residential units increased to about 175, 300, 300, and 160 respectively (Figure 12). Neither past nor future development, however, is expected to significantly alter the population of Gloucester, which continues to hover just above 18,000 persons. There has been only a slight population increase in the past few decades and only a 1.1 percent increase is forecasted between 1985-2010 (MAPC,1988b). Even though hundreds of new homes are expected to be built over this period, small population increases are expected because the average family size continues to decrease.

The major impact of the recent development boom is the loss of open space. A significant amount of the new construction has been taking place outside the pre-existing residential concentrations. A decade earlier, in 1980, city officials expected only minor development changes in these undeveloped areas, due to "geological constraints, wetland constraints, lack of utilities or access, and the constantly increasing costs of construction" (Gloucester General Plan, 1980).

The public concern for overdevelopment throughout Gloucester has focused on numerous large-scale subdivisions, and not on the scattered single home developments and small

FIGURE 12

GLOUCESTER RESIDENTIAL DEVELOPMENT: ACTUAL AND APPROVED
1982 - 1988



Source: Gloucester Master Plan, 1990.

subdivisions. Each new large subdivision project commonlyreaches the front page of the local newspaper at least three to four times, and numerous other segments and letters all usually referring to some controversial aspect(s) of the development.

Because large subdivision developments are relatively new to Gloucester, city officials and the public alike are often overwhelmed by the possible regional and city-wide impacts that could result. Gloucester has a relatively large and competent planning department, however, the rapid increase in large-scale subdivision proposals has made it difficult for city officials and the public to make decisions about development with potential environmental, social, and cultural impacts for many years to come.

The following four case studies are included below to illustrate the legal process of development in Gloucester and the evolution of POWTFs used in development proposals.

<u>Overlook at Wingersheek</u>

Originally proposed as a 65 unit condominium project in 1986 this development scaled down to include 25 single-family homes on 18 acres of land in West Gloucester. In order to fully maximize their development potential, this subdivision was to rely on two community leaching fields instead of individual septic systems for each lot. The city planning board viewed this as a clear violation of the state sanitary code and twice rejected the proposal (Ranalli, 1988a). The planning board would, however, permit such a system as long as each lot had the capacity to be served by an individual septic system. Due to the soil characteristics, it would have been impossible to use ISDS for each house-lot and would have meant a significantly scaled down project.

Wingersheek Golf Club

The Wingersheek Golf Club development proposal emerged in early 1989. If completed, it would be the largest subdivision in Gloucester. The plans called for between 200 to 300 exclusive homes situated around an 18 hole golf course. Including the price of the land, building the house, and a share in the golf course, the developers estimated that the average price of the homes would be around $400,000 (Bates, 1989). The massive development would be located on approximately 339 acres in West Gloucester and would utilize a never used cluster zoning ordinance, which allows for the use of smaller lot sizes if open space is given to the City. The developers propose to use the golf course as the trade-off in open space even though it would not be open to the public.

Like most of West Gloucester, the property is too shallow to bedrock with shallow water tables and wetlands near the surface, which would severely limit the use of ISDS. According to a member of the Gloucester Planning Board, the land could only handle about 70 houses, if traditional septic systems were used (Kirk, 1989). Instead, the developers plan to build a sewer line from the project and connect it to the nearest city-owned sewer line, located a few miles away. The developers claim their building of the sewer extension would not financially burden the City, and instead benefit the environment by allowing other nearby homes to tie into the sewer line. During an informational meeting with nearby residents, one strong concern was that by extending the sewer line it would allow other undeveloped properties to be developed (Bates, 1989).

A revised development plan was submitted which reduced the number of house sites to 279 and withdrew plans to utilize the open space ordinance due to problems stemming from defining open space in the case of a private golf course (Annis, 1990).

Mellville Estates

Mellville Estates was a controversial development proposal which exemplifies the potential impacts from the use of an on-site privately owned sewerage treatment plant. Located on only 20 acres of wooded land in the Magnolia Section of Gloucester, the developers had hoped to build a 100-unit condominium complex.

In order to entice the local authorities into allowing a special permit for the project, the developer offered to improve water lines in the area as well as set up a $200,000 fund to help first time home buyers within the City (Lang, 1988). To help with the City's affordable housing shortage, the developer additionally offered to sell five of the condominium units at an average price of $86,000 rather than the $220,000 average the others would have been listed for.

The city council never approved the development for numerous reasons, citing that the condominiums would be too expensive and out of character for the neighborhood. Opposing members of the city council also felt that the POWTF was an environmental threat to the nearby wetlands.

The developer responded to the denial with a lawsuit against the council, alleging in the suit that the city council was "arbitrary and capricious" and "exceeds the authority of the city council" (Gloucester Daily Times, 1988). Although the lawsuit failed, the development proposal was dropped due to the lack of economic viability.

Castle View Estates

At the time of its preliminary approval during the fall of 1986, the Castle View Estates development was the largest single family housing development proposed in the City in over five years. The subdivision involved a 140-acre parcel in West Gloucester on which a total of 119 individual homes were to be built. A combination of the magnitude of the project and the potential environmental impacts due to its proximity to protected coastal features lead to a lengthy review process involving the developer, city officials, state agencies and a local citizens organization.

The site of the development is located on the edge of one of the last remaining unpolluted clam flats, which is named Farm Creek. A Massachusetts Department of Environmental Quality Engineering (MDEQE) site review and on-site inspection noted numerous areas subject to protection under the Wetlands Protection Act including: 1)Bordering Vegetated Wetlands; 2)Inland Bank; 3)Land Under a Waterbody; 4)Salt Marsh; 5)Coastal Bank; and 6)Land Subject to Coastal Storm Flow (MDEQE, 1987). The DEQE review also identified other important areas of statutory interests such as: 1)Flood Control; 2)Storm Damage Prevention; 3)Public or Private Water Supply; 4)Ground Water Supply; 5)Prevention of Pollution; 6)Protection of Fisheries; and 7)Protection of Land Containing Shellfish. A small portion of the project site was also found to be within the Ipswich Area of Critical Environmental Concern (ACEC). Overall, however, the MDEQE found that their "Superseding Order of Conditions allowing the project serves to protect the interests of the Wetlands Protection Act, Massachusetts General Laws, Chapter 131, Section 40 (MDEQE, 1987).

During the early part of 1988, the Executive Office of Environmental Affairs received 17 letters requesting that a more extensive environmental review be conducted in accordance with the Fail-Safe Provision of the Massachusetts Environmental Policy Act (MEPA) 301 CMR 11.03(6). The Fail-Safe provisions allow a city or town to refer to the state projects, which have a "clear potential for causing damage to the environment, regardless of whether state permits are required" (Hoyte, p.1, 1988a). Previously, state reviews were only conducted when the State has a direct role in a development. The Massachusetts Coastal Zone Management Office (MCZM) and the Division of Marine Fisheries, in addition to the city officials, were among those requesting further study (Letter to James S. Hoyte, January 4, 1988). Their concerns, similar to others, focused on the potential impacts on the adjacent waterway from runoff and nutrient loading from septic systems. The EOEA eventually decided to order the Fail-Safe Review on February 19, 1988 because of the "public hardship which would be caused by the potentially irreversible pollution of this significant resource area" (Ranalli, 1988b). It was only the second time ever that the State had invoked the Fail-Safe provisions.

The Developers resisted the study. The City's Board of Health would not permit the septic systems on 46 of the housing sites. Suits and countersuits were being threatened by all parties. With most of the project in a dead-lock, the State Secretary of Environmental Affairs and the developers reached an agreement allowing the development of the first phase representing 55 house lots. The developer agreed to submit further environmental studies on the remaining sites. The initial agreement reduced the number of houses near the wetlands from eleven to five, and provided more precautions to handle drainage from the site into the marshland.

Essex Bay Estates at Coles Island

The Coles Island Subdivision Proposal was another large scale development with a history longer and more complex than that of the Castle Hill Project. It took a total of five years and four entirely different development strategies before a final construction plan was to be approved by state and local authorities. Two of the proposals included the use of a POWTF, thus making it a prime example for examining potential land use impacts.

The Coles Island Subdivision was to be located on 257 acres of land in West Gloucester, just across a salt marsh from the Castle View Development. The property has extensive coastal frontages with about 90 acres or approximately one-third of the entire site consisting of salt marsh wetlands (Coles Island E.I.R., 1988). Practically all of the surface drainage flows into these neighboring wetlands are included within the Ipswich Bay ACEC; hence, this was one of the reasons for much of the ensuing criticism for the development.

The details of the Coles Island Subdivision could be portrayed best by describing the history of each of the four subdivision plans submitted by the developers.

first proposal

During August of 1986, the development firm indicated to the Planning Board of Gloucester plans to develop a low density single family subdivision on the Coles Island Area of West Gloucester (Mass. Land Court, 1988). Following site inspections and a community meeting regarding the development, the Planning Board met and voted to recommend an increase in the minimum lot size in the region including the development site. The recommendation was for the land to be rezoned from a minimum lot size of 20,000 square feet to 80,000 square feet.

On October 23, 1986 the Essex Bay Limited Partnership submitted their preliminary plans showing 243 lots on the property as well as a petition against increasing the lot size prior to the development (Mass. Land Court, 1988). The plans were hastily put together and submitted in order to protect their development rights at the then existing minimum lot size of 20,000 square feet. Due to the filing of the protest petition, the City's attempts to increase the minimum lot size failed. With the small lot size zoning preserved, the developers withdrew their preliminary plans and began to develop a new plan with a substantially decreased development density.

second proposal

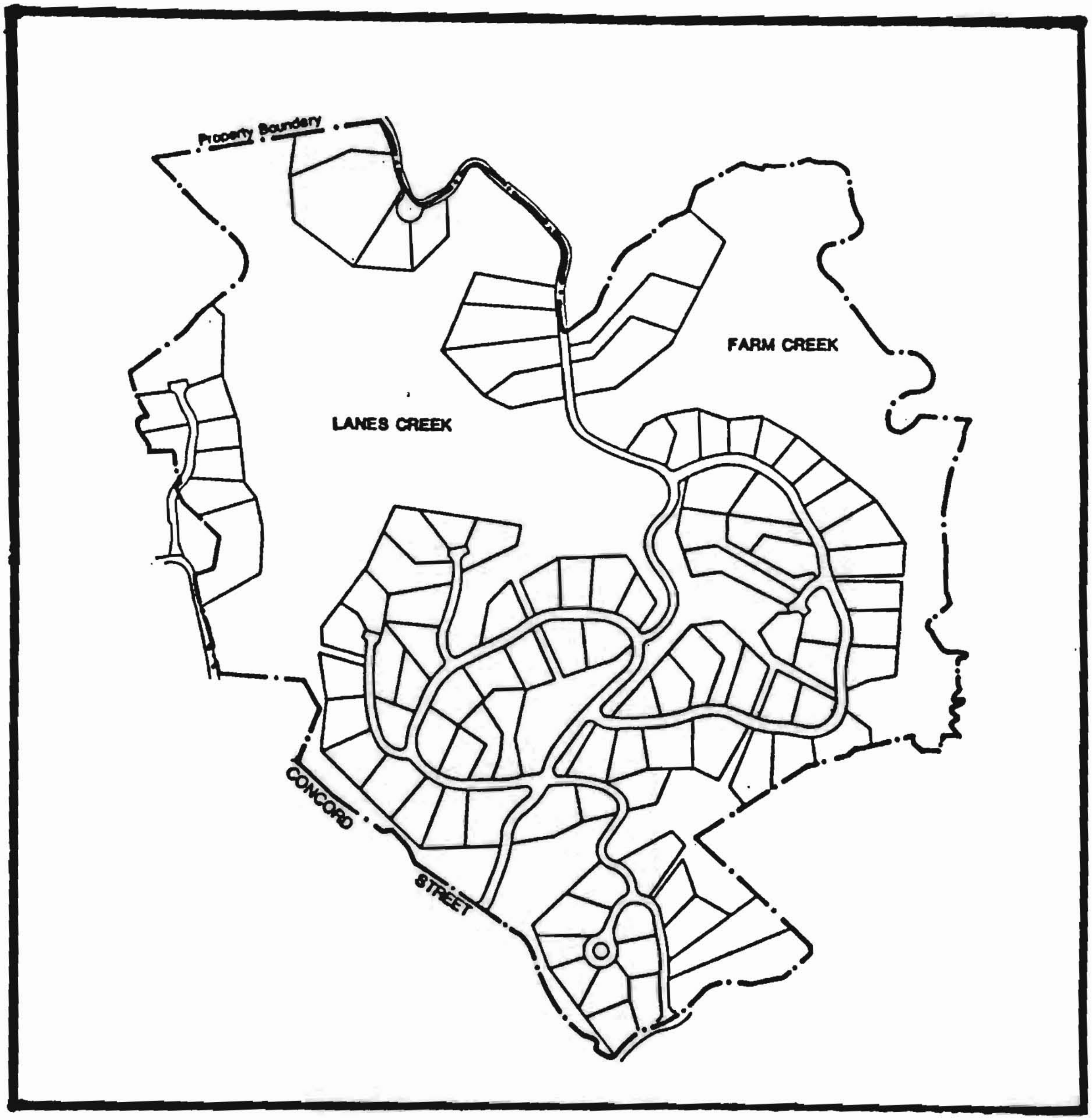
A new preliminary plan was submitted on January 16, 1987. However, during the interim between the previous proposal was submitted, the Board of Health attempted to revise its Rules and Regulations. The new rules, if adopted, would have imposed new requirements on developers relative to the size of water mains, fire protection and the adequacy of exterior access. These particular amendments were not passed until after the second preliminary proposal had been received (Gloucester Planning Board, 1987a). Nevertheless, the Planning board voted to disapprove the plan on other grounds such as ground layout, pavement widths and "suggested" that the applicant attempt to meet the recently added amendments to the Subdivision Regulations (Gloucester Planning Board, 1987b).

The preliminary proposal was revised to accommodate the Planning Board's requirements and suggestions, and was then submitted in the form of a definitive plan on July 2, 1987. This proposal included a total of 109 single-family lots; less than half the original preliminary plan (see Figure 13). Over 100 acres of open space, mostly in the form of unbuildable wetlands (Farm and Lanes Creek), were to be left undisturbed, leaving an average lot size of over one acre, more than twice the minimum size required by the zoning ordinance.

The soil conditions on the property were a severe limitation for the size of the development and would become the major problem between the developers and municipal officials. According to the developers own report, appropriate soils for ISDS are only found in small pockets

FIGURE 13

CASTLE VIEW ESTATES: 109 LOT ALTERNATIVE SUBDIVISION PLAN



Source: Castle View Environmental Impact Evaluation, 1987 in the higher elevations (Hayes Engineering, 1987). Hence, the definitive plan was contingent upon the construction of a POWTF, and the plans included a superficial description of its use.

The definitive plan was disapproved on August 7, 1987 by the Board of Health because the report did not contain sufficient information on the sewerage disposal system. The developers continued to negotiate with city officials at numerous meetings. The Planning Board and the Board of Health continued to thwart the developer's attempts to utilize a POWTF, and thus successfully prevented them from building the 109 house lot subdivision. The developers filed suit against the City on October 22, 1987, claiming that the Planning Board and the Board of Health over stepped their legal authority by stipulating the development must rely on ISDS.

During the fall of 1987, concerns were mounting state-wide about the use of POWTFs, and the response was great to the Coles Island Development. Similar to the Castle View case, numerous letters were filed to the EOEA, again calling for a complete environmental review under the Fail-Safe provisions as well as a state-wide moratorium and generic environmental impact review of POWTFs. Both the State Division of Marine Fisheries (Dec. 7, 1987), and Office of Coastal Zone Management (Dec. 8, 1987) called for additional impact studies expressing grave concern for the surrounding coastal environment, if the development proceeded as planned. Soon after, on December 14, 1987, the EOEA determined that the project would require the preparation of a complete Environmental Impact Report pursuant to the Massachusetts Environmental Act (MGL C. 30 s. 61-62h). The stated purpose of the report was to "analyze the direct and indirect environmental impacts relating to the wastewater treatment facility which would potentially allow for a greater intensity of development on the property" (Hoyte, 1987b). Soon after, the developers dropped their plans to utilize a POWTF and once again proposed to redesign the subdivision. In the interim, the Board of Health voted to prohibit the construction of a POWTF until they could adopt regulations for their use (Gloucester Board of Health, 1988).

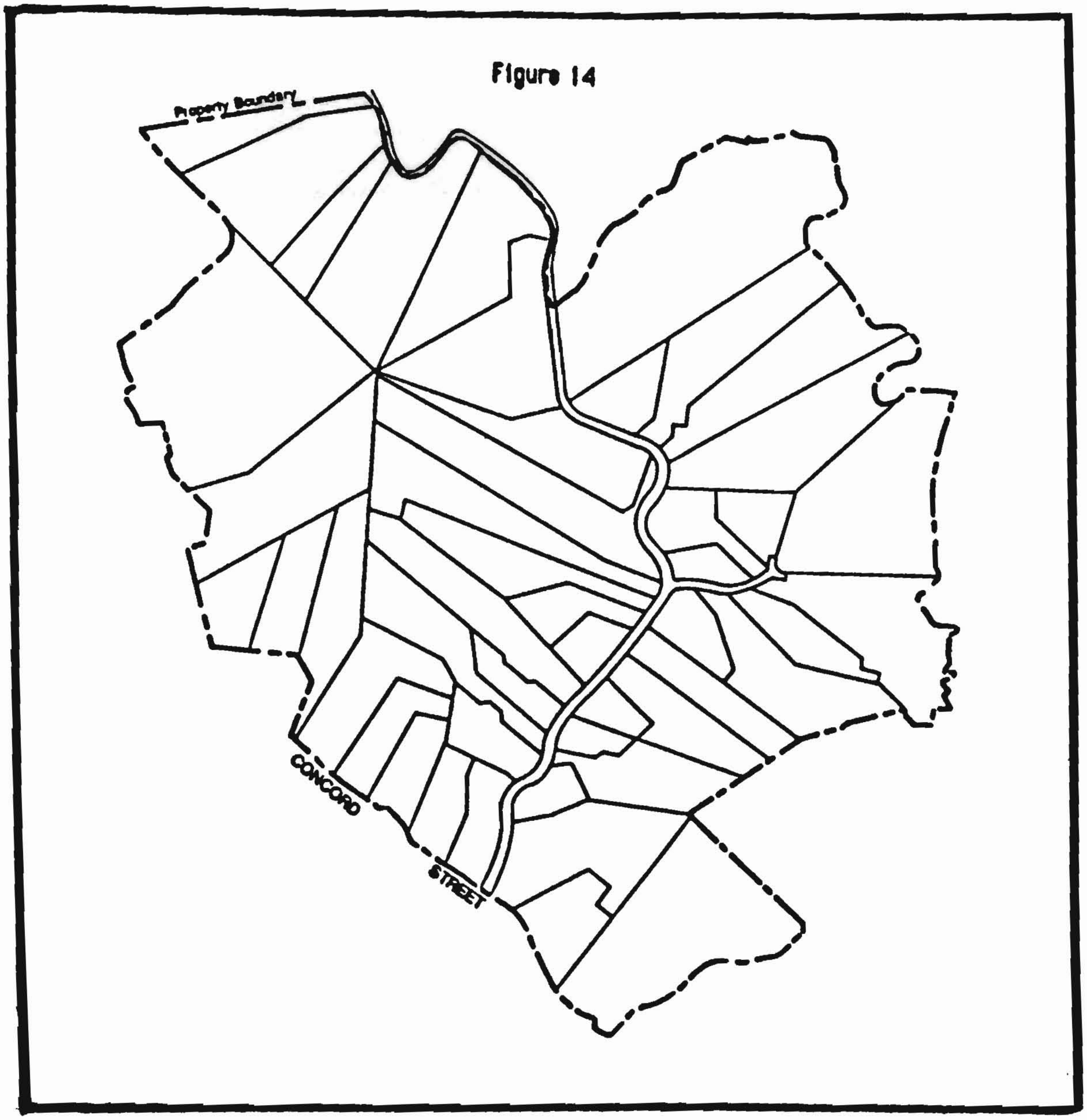
third proposal

A third revised subdivision plan for Coles Island reducing the number of lots by over half was presented to city officials on June 2, 1988. The developers withdrew their plans for a POWTF and hoped to accommodate only 44 lots with conventional ISDS (see Figure 14). This plan too was met with considerable opposition from city officials and local residents.

The potential environmental impacts to the surrounding wetlands from surface runoff, and a contention between the developers and city officials over the number of leaching fields the property could accommodate were the leading

FIGURE 14

CASTLE VIEW ESTATES: 44 LOT ALTERNATIVE SUBDIVISION PLAN



Source: Castle View Environmental Impact Evaluation, 1987.

problems of the revised subdivision plans. The developers proposed to share leaching fields between properties with inadequate leaching soils of their own. The Board of Health's restrictive conditions would not allow sharing of leaching fields and the developers again were forced to withdraw their subdivision plans.

fourth proposal

The final proposal for Coles Island met with little opposition. A new developer became partners with adjacent landowners and designed a 16-house lot subdivision that would minimize environmental degradation and still allow the developers to financially break even. The POWTF and shared leaching fields were entirely deleted, with each houselot possessing its individual leaching field. This plan was applauded by local and state officials and is expected to materialize when the housing market begins to grow again.

Land-Use Control in Gloucester

Gloucester has a wide range of regulations and permitting processes governing development and general land-use. The City has recently updated both its Comprehensive Plan (1990) and Open Space and Recreational Plan (1989), which provide policy recommendations for regulating new development, as well as preserving open space. Each expresses the overall perception that Gloucester needs many new land-use controls in order to restrict unwanted development, which could threaten the City's unique character and qualities.

Gloucester's new Comprehensive Plan includes extensive public input and took over three years to complete. The impetus for the Updated Plan was the extreme growth pressures of the 1980s. Within the plan are policies and objectives regulating housing, traffic, land-use and zoning, economic development, and community facilities and services such as water and sewage disposal. The Plan also recommends specific actions such as zoning changes, road improvements and increases in water or sewer services, and how to implement them via appropriate municipal agencies or regulations.

The recommendations within the Open Space and Recreational Plan are similar in ideals to that of the Comprehensive Plan. Both stress that Gloucester is under extreme developmental pressure, and that more should be done to preserve its unique character. The Plan acknowledges that Gloucester has extensive areas of open space and recreational facilities, but emphasizes that much of this property is prone to development. One major concern is that city-owned land is not properly protected from potential development, and thus it cannot be considered a permanent open space asset. The Open Space Plan recommends adopting a land protection policy, which would restrict development on city-owned open space conservation lands. A Conservation or Open Space Zoning Category along with further acquisitions have been recommended to further meet the open space demands of the future.

The evolution of some specific techniques and methods proposed to curb development and preserve open space are outlined below.

Zoning amendments

Various applications of zoning have been effectively utilized in Gloucester, to encourage the creation and protection of open space. In addition to simple minimum lot size increases, Gloucester officials have enacted both a Watershed Overlay District and innovative "cluster development" zoning options, which all can allow for development, while reducing the potential loss of open space.

Recommendations for numerous minimum lot size increases have been made over the past decade. For example in 1988 the Community Planning Department made some preliminary proposals for zoning amendments in practically every region of the City (Gloucester Planning Department, 1988). Five areas encompassing a total of 3,960 acres were recommended to have an increased minimum buildable lot size. It was calculated that if all of these zoning changes were enacted it would lead to a reduction of nearly 25 percent of the number of units that could be built under the existing zoning regulations. These changes can only be made without compensation, if the property is deemed to be unsuitable for the existing zoning category, for either physical or aesthetic reasons. These zoning changes all met with great reluctance from local property owners who feared lost property values. Some of these amendments have been passed, while others are still pending today..

A Watershed Overlay District was adopted by the City Council on January 10, 1989 as an amendment to the zoning laws. It includes all lands which contribute to the City's water supply. While not an outright ban on development within the watersheds, it did list a broad spectrum of prohibited "land uses, activities, devices, structures, and/or substances". The Amendment was intended to protect the quality of municipal drinking water, but will also indirectly lead to continued preservation of open space.

Board of health regulations

As previously discussed, the Municipal Board of Health's function is to ensure that septic systems are properly sited, designed, installed and maintained. There are two primary ways in which their regulations can indirectly restrict development. Most commonly, development is curtailed because the soils are not adequate to allow for the proper percolation of septic effluent. Secondly, the Gloucester Board of Health has a long list of regulations, in addition to minimum criteria set by the State. Many of these pertain to setback distances from natural and man made features for locating septic systems. City officials have been active at increasing setback distances greater than the State minimums, and thus indirectly preventing the potential development of many acres city-wide. For example, the State has no setbacks, the Gloucester Board of Health recently initiated a 200-foot setback distance from ACECs.

Housing moratorium

A housing moratorium has been proposed in Gloucester as a method for preventing development on short-term basis. Short-term development moratoriums have been utilized in many other cities. A permanent development moratorium would considered unconstitutional and deemed a "taking without compensation". Though never passed, a two-year moratorium was proposed by a City Council member in order to allow time to study the burgeoning development in Gloucester. Worries about a sudden rush to develop, prior to the enactment and confidence in the continuing City Planning Departments work prevented the idea from becoming a reality.

Subdivision regulations

The Subdivision Regulations are another important body of municipal law in Gloucester which govern land development (Gloucester Subdivision Rule and Regulations, 1988). The Planning Board has jurisdiction over reviewing and permitting subdivision plans and their compliance with these regulations. For example, the Planning Board reserves the right to require access easements, open space areas, grass plots and trees prior to allowing a development to be built.

CHAPTER VI

GLOUCESTER BUILD-OUT RESULTS AND DISCUSSION

Introduction

Chapter VI provides a detailed methodology, case study results, and a thorough discussion of the potential land-use impacts that the use of POWTFs could have on the City of Gloucester. The methodology consists of a step by step process incorporating physical and regulatory constraints, to determine the maximum developability of open space throughout the City using this technology. For comparison, the methodology provides data for development based on ISDS, as well as, the use of POWTFs. Though the results are dependent on local conditions, the discussion includes comparison with other similar studies and state-wide applicability of this methodology and results.

Methodology and Results

Determination of Minimum Parcel Size for Development

The use of a POWTF requires a parcel of a minimum size; thus, locating potential development sites meeting a minimum threshold size is required to assess the differential land

-use impacts between this technology and on-site septic disposal systems. This entails employing local zoning regulations, subdivision rules, site specific characteristics, and the economic limitations of utilizing a POWTF.

Size of treatment plant

Sewage treatment plants can be constructed to effectively service any number of housing units. However, to be a cost-effective alternative to septic systems, the economies of scale dictate that a minimum number of homes share in the costs. Those home-owners serviced by the facility must bare the costs of construction, yearly maintenance, and even possible replacement. A cost-effective development's size is also dictated by its location, style, and the income level of possible owners. An exclusive waterfront development could easily afford the higher costs of sewage treatment for a limited number of homes. Developments aimed at middle income homeowners, lacking unique location or services, would need to spread the cost of a POWTF over a greater number of homes. In general, the cost of a POWTF are too expensive for a small number of homes.

This study assumes that a plant size with a minimum capacity of 10,000 gallons, which services a corresponding number of homes, would be used. Small residential developments utilizing treatment plants in this size range have recently been proposed in the State (DEQE Ground Water Permits, May 4, 90). The Senior Community Planner of Gloucester agrees that this size treatment plant would be an economical alternative for residential development throughout many areas of the City (Gibbs, 1988). In other regions of the State, POWTFs are currently being used for condominiums and apartments, and other other relatively high density developments. Development proposals relying on POWTFs in Gloucester have previously been for only small, exclusive high-priced subdivisions, which could absorb the added costs without severely affecting their marketability. However, because of the "cookie cutter" pattern of most subdivisions, small subdivisions can greatly impact open space.

Number of housing units to be serviced

Houses of all sizes are built in Gloucester, but the average size usually includes three bedrooms (Gibbs, 1989). This thesis assumes the average single family house has three bedrooms. Bedrooms are the indicator used by the DEP to calculate septic effluent for each house (MDEQE, 310 CMR 15.02). Each bedroom is assumed to represent an average of 110 gallons per day. Based on these sewage estimate flows, a POWTF with 10,000 gallons per day of effluent could accommodate approximately 30 housing units. Therefore, the minimum sized development needed to compare the differential loss of open space between the use of ISDS and POWTFs includes a minimum of 30 residential homes of three bedrooms each.

Area for roads, utilities and open space

Gloucester's subdivision regulations contain requirements pertaining to the dimensions of roadways, sidewalks, and the placement of utilities. Subdivision approval by the planning board may also require the inclusion of small public use areas such as easements for open space, bike-ways, and walkways. The Planning Department of Gloucester estimates that on average, an additional 20 percent of a development area is required for these purposes in all zoning districts (Gibbs, 1988). Final development plans and site specific characteristics such as communal landscaping, preexisting roadways, and access to utilities can influence the quantity of space needed for these purposes. This thesis assumes that all potential development sites for a POWTF will include an additional 20 percent land area above what would be required to meet mimimum lot sizes.

Area for the treatment plant

The area needed for the treatment plant and leaching fields are dependent on site specific characteristics of the underlying soils, and the actual size of the development. The treatment plant itself is assumed to require an area approximately 1,000 square feet. The total area needed for leaching effluent is a function of the soil characteristics and the total quantity of effluent entering the ground. The DEQE guidelines for the effluent application area depends on both the percolation rate of the soils and the specific type of leaching system used (see Table 16). Based on these DEP guidelines, a POWTF with a flow of 10,000 gallons per day would require a leaching field in the range of 2,000 - 10,000 square feet. The guidelines also require a reserve leaching field, essentially doubling the area needed for subsurface disposal. Taking these State guidelines into account, this thesis assumes an average of 1.0 square foot of adequate soils is required for each gallon of effluent entering the ground each day.

Assuming an average buffer zone of 50 feet around both the leaching fields and the plant, a total of 41,980 square feet or 0.96 acres would be required for a POWTF of 10,000 gallons per day. Site specific soil conditions or larger developments could require a proportional increase in acreage for the leaching field based on the total number of gallons of effluent.

Local zoning constraints to parcel size

By incorporating the above assumptions with the minimum lot sizes defined in the Gloucester Zoning Ordinance, it is possible to determine the minimum parcel sizes which need further analysis for developability. Table 17 summarizes the land areas required to determine the minimum parcel size

TABLE 16

DEQE GUIDELINES FOR MINIMUM AREA FOR POWTF EFFLUENT DISPOSAL

Percolation Rate:	< 5 min/inch	5-10 min/inch	10-20min/inch*
	gal/day/sq.ft	gal/day/sq.ft	gal/day/sq.ft
Open Sand Beds	5.0	4.0	2.0
Leaching Pits	3.0	2.5	1.5
Leaching Chambers	3.0	2.5	1.5
Leaching Trenches	2.5	1.5	1.0

* Percolation rates in excess of 20 minutes per inch are considered unacceptable.

Source: MDEQE. Guidelines for the design, construction, operation and maintenance of small sewage treatment facilities with land disposal. Mass. DEQE, Second Draft, p. 85, January, 1988.

TABLE 17

GLOUCESTER MINIMUM PARCEL SIZE DETERMINATION

Zoning District	Min. Lot Size (sq. ft.)	30 Unit Area (sq. ft.)	Roads (20%) (sq. ft.)	Plant Area (sq. ft.)	Total (acres)
Rural Res. (R-RB)	80,000	2,400,000	480,000	41,980	67.1
Rural Res. (R-RA)	40,000	1,200,000	240,000	41,980	34.0
Low Den. Res. (R-2)	20,000	600,000	120,000	41,980	17.5
Med. Den. Res. (R-3)	10,000	300,000	60,000	41,980	9.2
High Den. Res. (R-4)	5,000	150,000	30,000	41,980	5.1

within each of the different residential zoning districts. The limiting parcel size is based upon the R-3 zoning district. R-3 is the most densely developed zoning category with a minimum lot size of 10,000 square feet, which would be permissible using POWTF technology. Undeveloped property, zoned R-4, within the region is serviced by public sewers (Brown, 1989). Thus, 9.2 acres is the minimum parcel size to be considered for further analysis.

Undeveloped Parcels in Gloucester

As part of the recently updated Comprehensive Plan, privately-owned undeveloped parcels throughout Gloucester have been identified (Gloucester Com. Plan., 1989). This plan identifies 224 individual parcels of undeveloped land, totaling approximately 3,285 acres. For regional comparison, each of the parcels has been separated into four geographic regions within the City of Gloucester: 47 located in North Gloucester; and 43, 70 and 66 in the East, Southwest, and West Regions, respectively (see Figure 15). Central Gloucester is excluded from this study because it is essentially fully developed, as well as sewered. The size of undeveloped parcels in Gloucester range from only 2.0 acres to 289.7 acres with an average of about 14.7 acres. The overall size of the parcels is extremely skewed towards the smaller size (see Figure 16). City-wide, 95 undeveloped parcels greater than 9.2 acres in size made up approximately 84 percent of all undeveloped property throughout the City

FIGURE 15

GLOUCESTER SUB-REGIONS

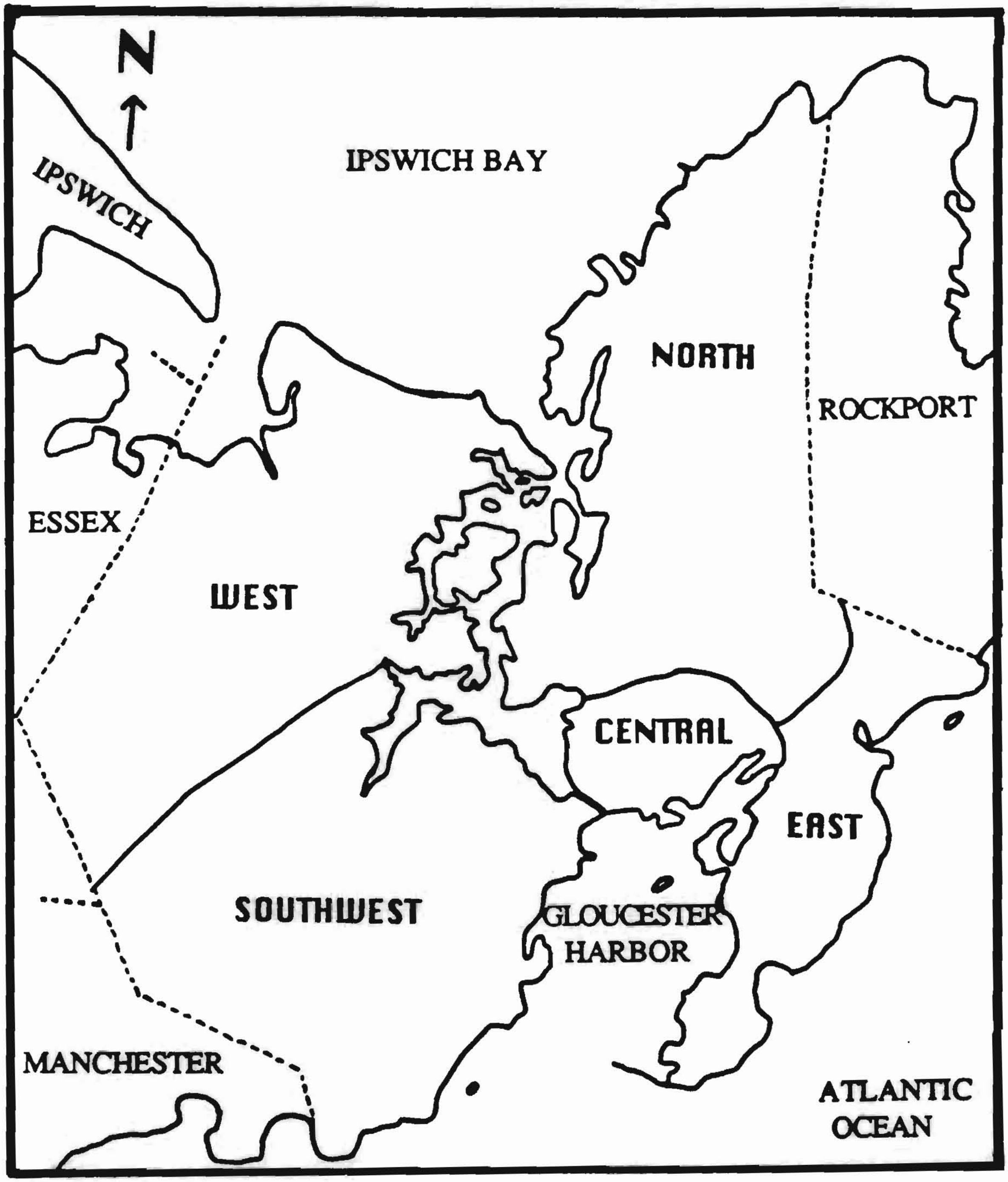
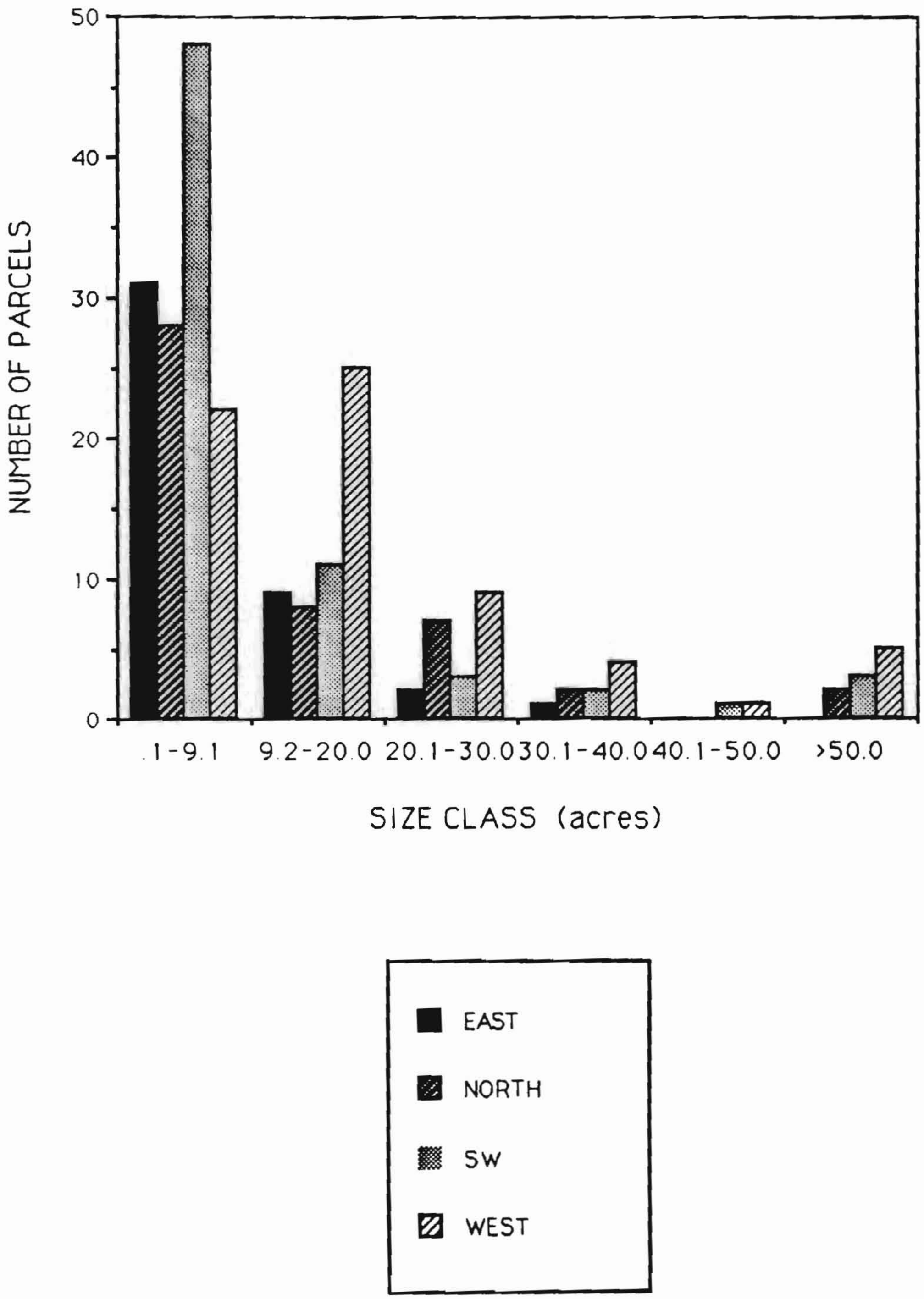


FIGURE 16

DISTRIBUTION OF GLOUCESTER'S UNDEVELOPED LAND



(see Figure 17). The remaining 129 parcels are less than the critical 9.2 acres determined neccessary for a POWTF. These smaller parcels are therefore eliminated from consideration for development using POWTF technology. Though combining small adjacent parcels to meet the threshold size is a possibility, this study only evaluates the development of indivdually-owned parcels.

Application of Zoning Constraints

Each parcel greater than 9.1 acres was located on City Platt Maps and City Zoning Maps to determine which zoning restrictions existed for each parcel. Minimum parcel size for a 30 unit subdivision utilizing a POWTF for each of the different zoning districts were previously determined are shown in Table 17 (page 159). Many parcels were located within two zoning districts. In these cases, a planimeter was used to measure the respective areas in each district. Portions of some areas were zoned for industrial (I-2), or for business (B-3) use. According to the Gloucester Planning Department, variances for a lesser use are usually permitted, so it was assumed that all areas zoned I-2 and B-3 would henceforth be considered developable under the R-2 zoning restrictions (Brown, 1989). The potentially developable land for each parcel was calculated by subtracting 20 percent for roads, and the appropriate area needed for the treatment plant with its leaching field. Table 18 lists each parcel with an area greater than 9.2

FIGURE 17

DISTRIBUTION OF GLOUCESTER'S UNDEVELOPED ACREAGE

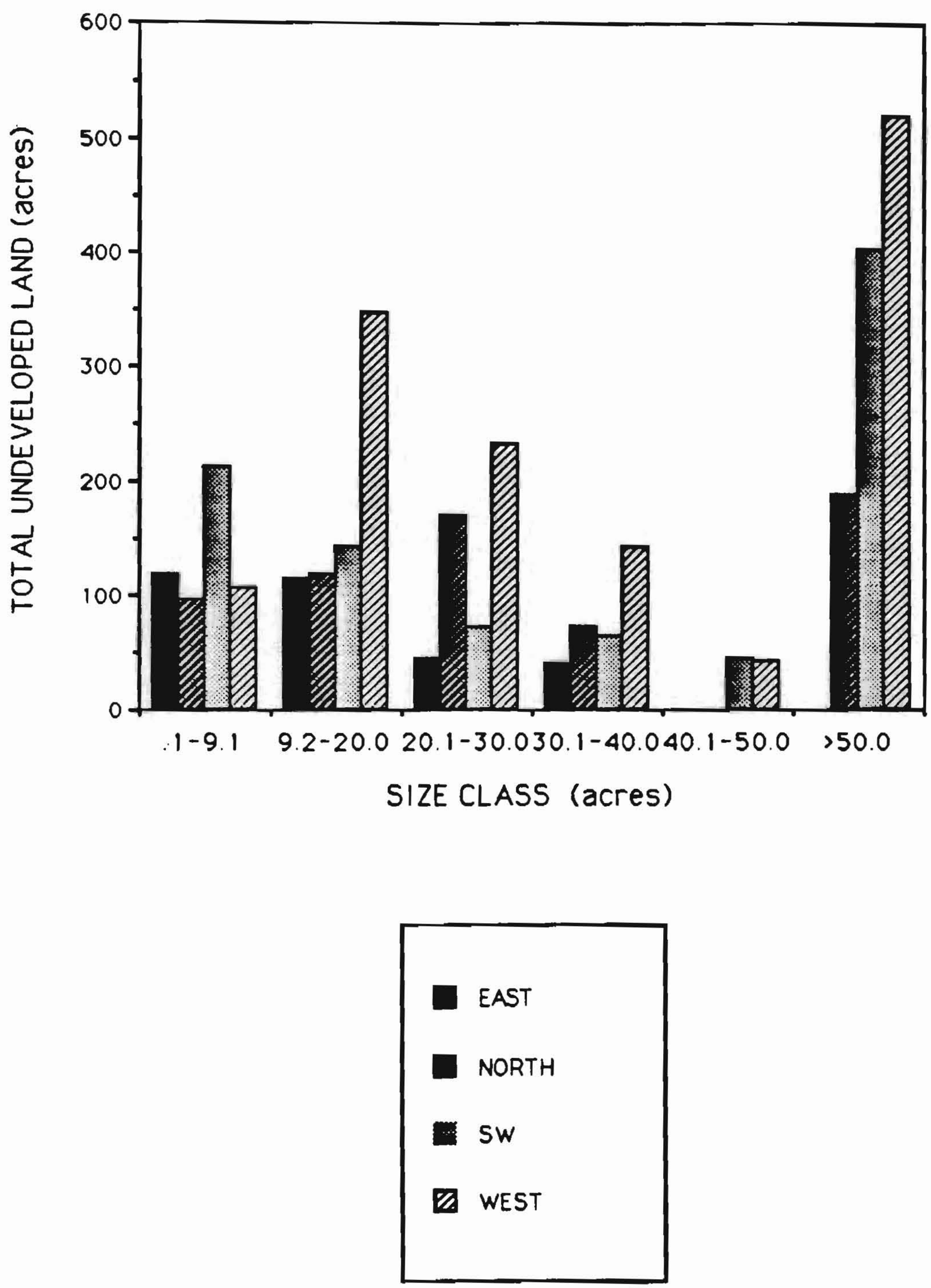


TABLE 18

ZONING CONSTRAINTS TO DEVELOPMENT POTENTIAL

Parcel	Size (acres)	Zoning	Roads (20%) (acres)	POWTF (arces)		# Houses
E- 1	11.6	R-RA	2.3	1.0		8
E- 2	12.7	R-RA	2.5	1.0		9
E- 3	22.0	R-RA	4.4	1.0		16
E- 4	22.6	R-RA	4.5	1.0		17
E- 5	19.1	R-RA	3.8	1.0		14
E- 6	13.0	R-2	2.6	1.0		18
E- 7	10.3	R-2	2.1	1.0		14
E- 8	10.4	R-2	2.1	1.0		14
E- 9	11.0	B-3	2.2	1.0		15
E-10*	16.7	R-3	3.3	1.2		48
E-11*	39.0	R-3	7.8	2.0		116
E-12	9.4	R-2	1.9	1.0		13
N- 1	11.2	R-2	2.2	1.0	a	16
	3.8	R-3	0.8	0	b	12=28
N- 2	27.4	R-2	5.5	1.1		41
N- 3	14.0	R-RB	2.8	1.0		5
N- 4	37.6	R-RB	7.5	1.0		14
N- 5	25.0	R-RB	5.0	1.0		9
N- 6	33.9	R-2	6.8	1.2		51
N- 7	11.0	R-2	2.2	1.0		15
N- 8	19.7	R-2	3.9	1.0		29
N- 9	133.0	R-RB	26.6	1.2		52
N-10	21.9	R-2	4.4	1.0		33
N-11	29.0	R-RB	5.8	1.0		11
N-12	22.8	R-RB	4.6	1.0		8
N-13	21.5	R-RB	4.3	1.0		8
N-14	22.0	R-RB	4.4	1.0		8
N-15	15.4	R-RB	3.1	1.0		5
N-16	18.0	R-RB	3.6	1.0		6
N-17	12.1	R-RB	2.4	1.0		4
N-18	7.6	R-2	1.5	1.0	a	10
	5.0	R-3	1.0	0	b	16=26
N-19	55.0	R-RB	11.0	1.0		21
SW- 1	50.2	R-3	10.0	2.4		151
SW- 2	32.5	I-2	6.5	1.2		49
SW- 3	51.7	R-2	10.3	1.9	a	78
	11.3	R-3	2.3	0	b	36=114
SW- 4	27.7	R-2	5.5	1.1		42
SW- 5	31.4	R-3	6.3	1.7		93
SW- 6	289.7	I-2	57.9	5.4		452
SW- 7	18.8	R-2	3.8	1.0		29
SW- 8	44.0	R-2	8.8	1.5		67
SW- 9	14.6	R-2	2.9	1.0		21
SW-10	9.5	R-2	1.9	1.0		13
SW-11*	12.8	R-3	2.6	1.1		36

*Sewered

TABLE 18

Parcel	Size (acres)	Zoning	Roads (20%) (acres)	POWTF (acres)	# Houses
W-12	13.0	R-2	2.6	1.0	18
W-13	24.0	R-2	4.8	1.1	36
SW-14	12.0	R-3	2.4	1.0	34
SW-15	16.5	R-3	3.3	1.2	47
SW-16	10.4	R-RA	2.1	1.0	7
SW-17	11.6	R-3	2.3	1.0	33
SW-18	13.1	R-3	2.6	1.1	37
SW-19	10.1	R-RA	2.0	1.0	7
SW-20	20.0	R-3	4.0	1.2	55
W- 1	10.1	R-RB	2.0	1.0	3
W- 2	49.9	R-2	10.0	1.8	a 389.4
	7.8	R-3	1.6	0	b 24.8=101
W- 3	10.0	R-2	2.0	1.0	14
W- 4	13.8	R-2	2.8	1.2	a 19
	11.2	R-3	2.2	0	b 36=55
W-5	16.0	R-2	3.2	1.0	23
W- 6	30.5	R-2	6.1	1.2	46
W- 7	32.0	R-2	6.4	1.2	48
W- 8	29.0	R-2	5.8	1.1	44
W- 9	26.0	R-2	5.2	1.1	39
W-10	10.0	R-2	2.0	1.0	14
W-11	10.0	R-2	2.0	1.0	14
W-12	14.3	R-2	2.9	1.0	20
W-13	249.6	R-2	49.9	5.1	a 389.4
	7.5	R-3	1.5	0	b 23.6=413
W-14	18.0	R-2	3.6	1.0	26
W-15	18.5	B-3	3.7	1.0	6
W-16	78.0	R-RA	15.6	1.0	30
W-17	17.5	R-2	3.5	1.0	26
W-18	10.9	R-2	2.2	1.0	15
W-19	19.8	R-2	4.0	1.0	29
W-20	25.0	R-2	5.0	1.1	37
W-21	22.8	R-2	4.6	1.0	34
W-22	20.0	R-2	4.0	1.0	30
W-23	10.0	R-2	2.0	1.0	14
W-24	29.7	R-2	5.9	1.2	45
W-25	39.8	R-3	8.0	2.0	119
W-26	38.2	B-3	7.6	2.6	a 56
	36.6	R-3	7.3	0	b 117=173
W-27	11.7	R-3	2.3	1.0	33
W-28	13.0	R-3	2.6	1.1	37
W-29	22.4	R-2	4.5	1.1	a 33.6
	2.6	R-3	0.5	0	b 8.4=42
W-30	10.0	R-3	2.0	1.0	28
W-31	22.0	R-3	4.4	1.3	65
W-32	42.0	R-3	8.4	2.1	126
W-33	12.0	R-3	2.4	1.0	34
W-34	11.0	B-3	2.2	1.0	3
W-35	11.0	B-3	2.2	1.0	3

TABLE 18

Parcel	Size (acres)	Zoning	Roads (20%) (acres)	POWTF (acres)		# Houses
W-36	17.5	R-3	3.5	1.2		51
W-37	5.5	R-RB	1.1	1.0	a	1.7
	6.7	R-3	1.3	0	b	21.6=23
W-38	18.0	B-3	3.6	1.0		6
W-39	53.3	B-3	10.7	1.0		20
W-40	15.8	B-3	3.2	1.0		5
W-41	27.0	R-2	5.4	1.1		41
W-42	39.3	B-3	7.9	1.0		15
W-43	19.7	B-3	3.9	1.0		7
W-44	9.9	R-2	2.0	1.0		13

acres and supplies the information required to calculate maximum developability based on zoning.

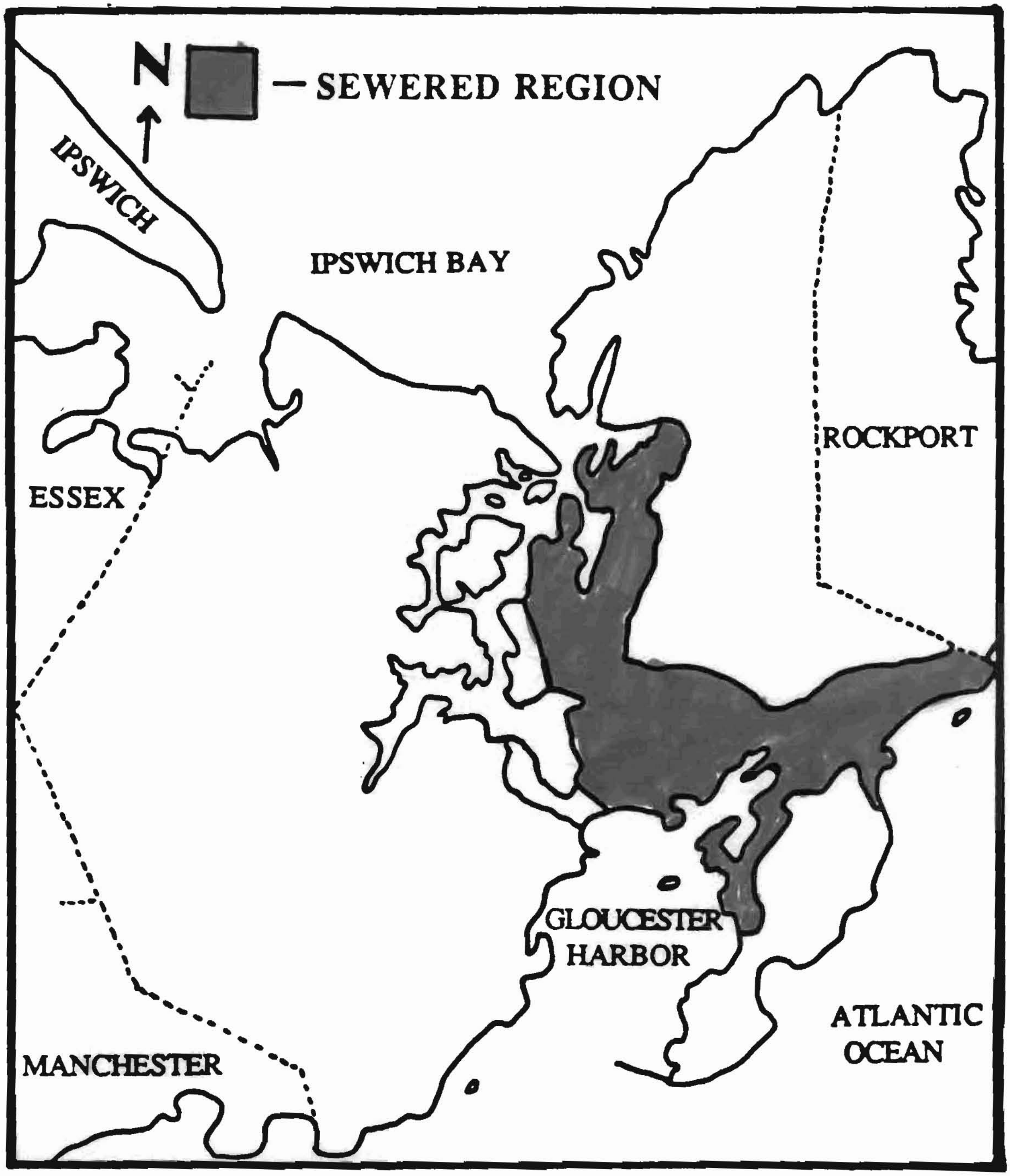
Zoning constraints combined with the area needed for the treatment facility and roads limited the number of parcels to 42 which could potentially accommodate a 30-unit subdivision. Many parcels would be large enough to accommodate 30 houses, if they were in the next less restrictive zoning category. This is the situation in the eastern and northern regions of the City, where existing development, smaller lot sizes and restrictive zoning of development sites has limited the number to only six parcels (271.9 acres). In what is referred to as the west and southwest portions of the City, there are 36 parcels totaling 1566.1 acres, all of which based on zoning, could accomodate 30 or more homes. All total, the 42 parcels still encompass over 55 percent of the property available for development in the City.

Sewered Acreage and Parcels

Municipal law in Gloucester dictates that any new development with access to municipal sewer lines must tie into the system. Gloucester has a large secondary sewerage treatment plant which services the central region and a small part of the rest of the City (see Figure 18). The option to extend municipal sewering does exist, although it becomes prohibitively expensive with increasing distance from the existing system. Three parcels large enough to

FIGURE 18

SEWERED REGION OF GLOUCESTER



meet the minimum parcel size, based on zoning restrictions, are located within the region serviced by the city sewerage system. These include two parcels in the east and one in the southwest of Gloucester totaling about 68 acres of property. These parcels are eliminated from further review in this thesis, since they will presumably not be limited by sewerage treatment options.

Wetlands Constraints

The Massachusetts Wetlands Protection Act (1962) includes many regulations which restrict development in and around water-bodies and wetlands. The Act empowers local Conservation Commissions to delineate boundaries, enforce at a minimum the guidelines set forth in the Act, and assess impacts of all development proposed within 100 feet of a wetland boundary. Regulations under the Act determine the setback distances for septic systems and buildings of residential development from such stated water bodies and wetlands. The proposed location of a septic system must be a minimum of 100 feet from the wetland boundary, however, a building may be built as close as 50 feet without needing a special permit or variance. Setbacks are intended to be a general rule of thumb, though site specific characteristics such as soil conditions or proximity to fragile habitat could allow the City to increase the setback distance.

Based on the minimum setback distance of the building and not of the septic system, this thesis assumes that no development will be permitted within 50 feet of a wetland. The septic system can be located on a different part of a property, one which is probably less influenced by the characteristics of the wetland, thus, probably more appropriate for its location. Therefore, the area encompassed by a wetland and a 50-foot buffer around it is subtracted from each parcel and the corresponding reduction in potential housing is calculated.

Wetland impact on developability of parcels

Wetland maps constructed by the Gloucester Conservation Commission were utilized to calculate the total area of wetlands and the 50-foot buffer for each of the 39 parcels remaining in the study area. Wetlands and the updated maximum development calculation are shown in Table 19. In each case where wetlands or wetland buffers were identified in parcels, the area required for roads was recalculated to accomodate the reduced area available for development. A similar but less significant area for the POWTF was recalculated based on the reduced number of residential units.

The impacts of wetlands varied from parcel to parcel. All of the 39 parcels contained some areas of wetlands or buffer and two (w-27, w-28) were found to be composed entirely of wetlands. Overall about 456 acres, or 26

TABLE 19

WETLANDS CONSTRAINTS

Parcel	Size (acres)	Zoning	Wetlands (acres)	Roads (acres)	POWTF (acres)	Develop. (acres)	Max. Units
N- 2	27.4	R-2	5.3	4.4	1.0	16.7	33
N- 6	33.9	R-2	8.3	5.1	1.1	19.4	39
N- 9	133.0	R-RB	43.1	18.0	1.0	70.9	35
N-10	21.9	R-2	6.0	3.2	1.0	11.7	23
SW- 1	50.2	R-3	6.8	8.7	2.1	32.6	150
SW- 2	32.5	I-2	8.9	4.7	1.0	17.9	35
SW- 3	51.7	R-2	24.7	5.4	1.6	15.1	a 40
	11.3	R-3	0.0	2.3	0.0	9.0	b 36=76
SW- 4	27.7	R-2	0.1	5.5	1.1	21.0	42
SW- 5	31.4	R-3	4.0	5.5	1.6	20.3	81
SW- 6	289.7	I-2	37.0	50.5	4.8	197.4	394
SW- 8	44.0	R-2	9.3	6.9	1.2	26.6	53
SW-13	24.0	R-2	9.4	2.9	1.0	10.7	21
SW-14	12.0	R-3	2.3	1.9	1.0	6.8	27
SW-15	16.5	R-3	11.6	1.0	1.0	2.9	11
SW-17	11.6	R-3	0.0	2.3	1.0	8.3	33
SW-18	13.1	R-3	1.6	2.3	1.0	8.2	32
SW-20	20.0	R-3	4.5	3.1	1.1	11.3	45
W-2	49.9	R-2	0.4	9.9	1.8	37.8	a 75.6
	7.8	R-3	0.0	1.6	0.0	6.2	b 24.8=100
W- 4	13.8	R-2	1.4	2.5	1.2	8.7	a 17
	11.2	R-3	0.0	2.2	0.0	9.0	b 36=53
W- 6	30.5	R-2	9.3	4.2	1.0	16.0	32
W- 7	32.0	R-2	8.0	4.8	1.1	18.1	36
W- 8	29.0	R-2	0.0	5.8	1.1	22.1	44
W- 9	26.0	R-2	5.2	4.1	1.0	15.7	31
W-13	249.6	R-2	79.6	34.0	3.7	132.3	a 264.6
	7.5	R-3	2.2	1.1	0.0	4.2	b 16.8=281
W-16	78.0	R-RB	29.4	9.7	1.0	37.9	18
W-20	25.0	R-2	5.0	4.0	1.0	15.0	30
W-21	22.8	R-2	0.0	4.6	1.0	17.2	34
W-22	20.0	R-2	2.9	3.4	1.0	12.7	25
W-24	29.7	R-2	5.4	4.9	1.1	18.3	36
W-25	39.8	R-3	13.2	3.3	1.7	21.6	86
W-26	38.2	B-3	29.3	1.8	1.2	5.9	a 11.8
	36.6	R-3	25.5	2.2	0.0	11.1	b 44.4=56
W-27	11.7	R-3	11.7	0.0	1.0	0.0	0
W-28	13.0	R-3	13.0	0.0	1.0	0.0	0
W-29	22.4	R-2	21.1	0.3	1.0	0	a 0
	2.6	R-3	0.0	0.5	0.0	2.1	b 4=4
W-31	22.0	R-3	3.3	3.7	1.2	13.8	55
W-32	42.0	R-3	4.9	7.4	1.9	27.8	111
W-33	12.0	R-3	1.7	2.1	1.0	7.2	28
W-36	17.5	R-3	0.9	3.3	1.2	12.1	48
W-41	27.0	R-2	0.0	5.4	1.1	20.5	41

percent of the total area, was deemed undevelopable due to the presence of wetlands. The wetland area corresponded to a reduction of close to 28 percent of the potential housing development units. The percentage difference between wetland area and housing development is attributed to the variation in minimum lot sizes for each parcel.

The number of parcels which could still accommodate a minimum of 30 housing units is reduced to 29. These 29 parcels still represented a large percentage of potentially developable land throughout the City, totaling about 913 potentially developable acres.

Soil Conditions Influencing Developability.

Soils play an important role in determining the developability of land. Nationwide, there are nearly a hundred thousand different classifications of soils, each possessing a unique set of characteristics which can act to either promote or limit potential development (Kellog, 1966). In particular, the ability of a soil to effectively support a septic system is often the limiting variable in estimating the developability of land. Proper septic system operation is influenced by soil criteria such as permeability, slope, depth to seasonal high water or bedrock, and depth of pervious material. Generalizations about soil types are valuable for large scale planning purposes, but the proper use of septic systems requires on-site soil inspections to verify conditions.

Many different models utilizing soils information have been developed to determine the suitability of land for subsurface wastewater disposal. Some are intended to be a tool for only large-scale regional planning purposes while others have been refined, with enough detail, to be used for site specific land-use decisions involving subsurface wastewater disposal. All models utilize, at least partially, identification and descriptions of soils provided by the USDA Soil Conservation Service (SCS).

Regional soil surveys by the SCS include conclusions from their own models for judging the suitability of soils for subsurface wastewater disposal. However, conclusions made by the SCS are considered to be overly conservative and are not indicative of future development. For example the SCS rates 100 percent of the soils of Essex County, which includes Gloucester, as severe for use as septic tank absorption fields, even though there are countless successful systems functioning throughout this region (Soil Survey Essex County, 1984). Therefore, SCS recommendations are limited in value for planning purposes. The actual SCS data are however, considered to be generally accurate, and their conclusions about soils are relatively correct with several limitations being worse than moderate (Wolfson, 1983).

Other models of various complexity utilizing SCS information exist for evaluating land for subsurface wastewater disposal. The State of Maine, for example, has devised a model called "The New System Variance Procedure", which is proposed to replace the existing system and focuses predominantly on the depth of seasonal high water or impervious layers (Hoxie et. al., 1988). Instead, the proposed model, considered more comprehensive, assigns point values for SCS data and other variables such as size of property, terrain, type of development, treatment system, and others. Minimum point totals would be required for consideration of a subsurface disposal system with higher values needed in coastal areas or lots in proposed subdivisions. The "Maine" model is rather complex and applicable at the municipal planning level for individual lot evaluations.

Other models have been evaluated which focused more on large scale regional planning by not incorporating as much site specific data as the "Maine Model" (Amato, 1974; Steele, et. al., 1986; MAPC, 1988; and Clark Engineering, 1989). Because each of these models relies predominantly on SCS data alone, they include many assumptions which prevent their utility at the site specific level. Municipal Boards of Health need to incorporate site speicifc data in determining whether or not a parcel of land is suitable to accommodate subsurface wastewater. However, due to the pure logistics of conducting soil surveys beyond the depth of those by the SCS, large scale models can be of great value at the municipal level for projecting future potential development. Such information can be used to solicit public comment in regards to how a municipality should be developed in the future as well as provoke efforts to update and amend an existing Master Plan

Soil developability model for Gloucester

A unique soils developability model for Gloucester is created by combining local soils data with applicable state and municipal regulations controlling subsurface wastewater disposal. This model supplies the final information needed to make projections and comparisons between the potential development resulting from the use of ISDSs or POWTFs throughout the City. The model relies heavily on data from the SCS "Soil Survey of Essex County" (USSC, 1984), and is also supported with local site specific data from previous development proposals in order to increase its validity. The emphasis of the model is to evaluate those characteristics, both individual and acumulative, of the underlying soils that would be most apt to prevent development which relied on either subsurface wastewater treatment or connection to a POWTF. The model initially assumes a 100 percent developability factor for all soils which is then reduced depending upon the individual characteristics of each soil type.

slope

In relation to soils, slope is simply defined as the rise over the run. Irrespective of other factors, the affects of slope can have a great impact on the developability of land. Extreme slopes can cause problems for building development due do to erosion and/or excessive engineering needed to securely locate a building. A more important problem related to steep slopes is that they often restrict the use of septic systems. Slope can cause construction problems for an ISDS as well as increase the possibility of outflow of septage down the slope, moving away from the leaching field.

The SCS soil survey of Essex County supplies data on the slope of individual soil types found throughout the region (USSCS, 1984). In addition, the SCS rates soils for their suitability for subsurface wastewater disposal based on different slopes (see Table 20). The SCS does not directly indicate which slopes are appropriate for an ISDS, but instead provides a table recommending suitability of different slope categories. Other research, which has evaluated the impacts of slope on developability has, however, provided the next step toward making quantitative assumptions relative to developability. For example, in one study, slopes as steep as 15 to 25 percent were considered 100 percent developable by employing mitigative technologies such as grading (Clark Engineering, 1989). Another report focusing on subsurface disposal, assumed that any slope less than 15 percent is 100 percent developable with mitigative procedures, and slopes greater than 15 percent is 100 percent undevelopable (MAPC, 1988a). There are no clear

TABLE 20

SOIL CONSERVATION SERVICE SLOPE CLASSIFICATION AND THE ASSUMPTIONS FOR PERCENT DECREASE IN DEVELOPABILITY

Percent Slope	SCS Limitation	Percent Sewered	Percent Septic	Percent POWTF
0 - 3	Slight	0	0	0
3 - 8	Slight	0	0	5
3 - 15	Moderate	5	10	15
8 - 15	Moderate	10	25	40
15 - 25	Severe	15	35	100
15 - 35	Severe	25	50	100

Note: Percentages represent the slope partial percentage to be subtracted from 100% acreage of a parcel which could be developed.

Source: USSSC. Soil Conservation Services, Essex County Soil Survey, Sothern Part. 1984.

thresholds for slope developability, and practically any slope could be made usable for an ISDS with enough mitigative action, however, such assumptions do not consider the cost-effectiveness in a real development situation.

The model used in this thesis utilizes the slope information supplied by SCS to its fullest. Seven different ranges of slopes are found on the parcels being evaluated for the impacts of POWTFs. Slope limitations are evaluated separately for three sewerage scenarios: 1) for individual septic systems; 2) a POWTF leaching field; and for the situation where houses are connected to a treatment plant (See Table 20, p. 178). Those lots requiring only a sewer line hook-up to a POWTF would be limited by slope only by the affects of slope on the above-ground construction and any added costs to install the piping. Leaching fields, on the other hand, become increasingly limited in the quantity of effluent they can handle with increasing slope. State regulations for POWTF leaching fields restrict them from being located within 50 feet from any slope greater than 33 percent. Though no specific regulations for siting POWTFs on slopes presently exist, this thesis assumes that any slopes greater than 15 percent are unsuitable for that purpose and have only limited use for grades between eight and fifteen percent. Individual septic system leaching fields are assumed to be acceptable in increasingly limited percentage at all slope gradients, with the assumption that grading can make some of the steeper slopes adequate. At this point, it must be stressed that slope developability rates are independent of all other criteria and do not represent an actual scenario until the other variables are included.

permeability and percolation rates

The permeability of a soil is an important characteristic for determining suitability for subsurface wastewater disposal. Permeability is a measure of downward movement of water. Influenced by many physical parameters, permeability rates vary over short distances from one soil type to another. Particle size, arrangement, and compaction can all influence of permeability. Clays, for example are generally not a good soil for septic systems because they consist of very small flat particles, which restricts the flow of liquid. The permeability of the soils in a potential leaching field must be determined, in order to assess the appropriateness of such a use. Soils that are too permeable can allow septic effluent to enter groundwater sources before soil actions can properly break down disease causing organisms, thus threatening public health. Likewise, soils which permeate septic effluent to slowly can essentially backup and pour out onto the surface.

Information on permeability of different soils in the Gloucester Region is available from the Essex County Soil Survey. The Survey provides permeability data on soils from the surface to approximatley five feet in depth and makes relative recommendations about their use for an ISDS (See Table 21). However, State regulations within Title V pertaining to soils do not utilize permeability data, but instead use the percolation test. A percolation test measures water infiltration and movement in terms of minutes per inch while permeability is measured by the SCS in terms of inches per hour. The difference between the two standards is more than just an inversion of the units. Percolation tests incorporate different assumptions, such as not taking into account the height of the water in the hole or the depth to a restrictive layer beneath the soil surface. Therefore, permeability data cannot be converted to percolation results by simply inverting the units, but it is possible though a complex model devised precisely for this purpose (Lurie, 1988). This model determines that the maximum percolation rate allowable by Title V, at 30 minutes per inch, is roughly comparable to a minimum permeability of 0.31 inches per hour.

The soil developability model for Gloucester utilizes the conversion equation and assume that all soils with a permeability of less than 0.3 inches per hour are unsuitable for subsurface wastewater disposal. Permeability rates are used from the soil horizon between two and five feet in depth. Shallower depths often have favorable permeabilities. However, surface soils have little influence on the function of a septic system leaching field, because the distribution pipes are usually placed about four

TABLE 21

SOIL CONSERVATION SERVICE PERMEABILITY CRITERIA AND LIMITATIONS FOR USE FOR SEPTIC SYSTEMS

Classification	Range	Limitation
Very Slow	<0.05 in/hr	severe
Slow	0.05-0.2 in/hr	moderate
Moderately Slow	0.2-0.8 in/hr	moderate
Moderate	0.8-2.5 in/hr	slight
Moderately Rapid	2.5-5 in/hr	slight
Rapid	5-10 in/hr	slight
Very Rapid	>10 in/hr	severe

Source: USSSC Soil Conservation Services, Essex County Soil Survey, Southern Part. 1984.

feet below the surface. Because Gloucester presently does not have in place maximum permeability rates, it is assumed that rapid permeable soils will also be appropriate for disposal. However, many towns such as those on Cape Cod, which rely almost solely on groundwater for drinking, are beginning to enact maximum permeability rates to protect these resources.

Many permeability ranges exist in the soils found in Gloucester, some of which are both acceptable and nonacceptable for development, depending upon the mode of sewerage treatment proposed (See Table 22). Similar to the slope criteria, developability rates are weighted for soil types whose permeabilities range into both categories. The values in Table 22 represent a percentage decrease in the developability depending upon the treatment option, and the permeability of the underlying soils. The concentrated localization of wastewater from a POWTF (i.e. 10,000 gpd) necessitates a larger decrease in potential developability, and no loss of developabiltiy results when a house does not rely on subsurface disposal.

depth to bedrock

Throughout Gloucester, exposed and shallow deposits of bedrock are the single most important deterrent to development proposing subsurface disposal. Inadequate soil depth restricts the proper treatment of sewerage effluents, and can cause the liquids to pool up above the bedrock and

TABLE 22

PERMEABLILITY RANGES AND THE CORRESPONDING PERCENT DECREASE

IN DEVELOPABILITY FOR GLOUCESTER SOILS

Permeability(in/hr)	Sewered(%)	Septic(%)	POWTF(%)
<0.2	0	100	100
0.06-0.2	0	100	100
0.06-0.6	0	90	100
0.2-0.6	0	25	40
0.2-20.0	0	0	0
0.6-6.0	0	0	0
6.0-20.0	0	0	0
>6.0	0	0	0
>20.0	0	0	0

Source: USSSC, 1984.

reemerge above the surface. State regulations within Title V require a minimum of four feet of soil "free of impervious material such as layers of clay, silt, subsoil or loam". The SCS soil survey supplies general information on bedrock depth, but on-site inspections are needed to verify conditions.

The Chatfield Soil Series (CrC & CrD) is common in many areas of Gloucester and in practically all parcels investigated in the study area. The SCS rates this soil series as reaching "unweathered rock" at only 34 inches. However, this series has been shown in Gloucester to contain quite a bit of natural variation with respect to the depth to bedrock. Obviously, this can be assumed to be an average figure with a wide range of depth to bedrock actually existing. The City Planning Department supports this assumption through many on-site inspections which have revealed soil depths in excess of five feet in soils claimed to be either CrC or CrD (Gibbs, 1989). For example, at the Coles Island Development, test holes found soil depths of about six feet where the SCS data indicates only 34 inches (Coles Island Report, 1988).

Utilizing the relatively simple technology involved with mound systems for leaching fields, many shallow depth soils could still be viable development sites. Mound systems are constructed by mounding permeable fill material on top of the existing top soil; in affect, creating soils deep enough soils for subsurface wastewater to be adequately treated as it passes through them. Though cost is a factor, mound systems can be appropriately used on marginal land where a conventional ISDS would not be approved. Together with variations in bedrock depths, the soils developability model assumes a 60 percent loss of developable land, due to this factor, for single home septic systems. It also assumes that POWTF discharges would be completely (100% undevelopable) inappropriate for these soils. Exposed rock and shallow depths to bedrock are assumed to be entirely developable with houses with access to a POWTF located on alternate land.

depth to seasonal high water table

The depth of the seasonal high water table (SHWT) is another important factor for determining developabiltiy of land throughout Gloucester. High water tables are locally common in much of the undeveloped sections of the City and pose a major constraint to future development of these areas. Development which would rely on subsurface wastewater disposal, such as that which exists in most of the undeveloped regions, would be the most affected by the presence of a restrictive SHWT.

There are many variables of the SHWT to consider for determining what types of development are possible. Each soil type possesses its own characteristics, influenceing the capability of the soil to accept and effectively handle infiltration of wastewater. Water tables vary in their proximity to the soil surface and their duration at seasonally elevated levels. Where the water table is near or at the surface for much of the year, wetland conditions result. In other soil types, the SHWT may only come within a few feet of the surface during the peak rain and runoff seasons in late winter and early spring.

Two distinctly different types of SHWTs are present in Gloucester's soils. An apparent water table is one which consists of a thick zone of free water in the soil. This type is usually characteristic of wetlands, and for the study area they are considered undevelopable under any circumstances, due to rather strict control of alteration of these areas. The other type, termed a perched water table, generally does not indicate wetland areas, and thus is potentially developable. Perched water tables consist of a zone of water standing above an unsaturated zone. Theses conditions are caused by the presence of a fragipan, a subsurface layer of extremely dense or compacted soil, which acts to restrict the infiltration of water entering the soil. The presence of a fragipan does create constraints to development, but a potential for mitigation exists by either puncturing or actually excavating the impermeable layer and replacing it with a soil which allows for infiltration of water entering the soil. Mound systems can also be utilized to facilitate development which could have otherwise been denied because of a perched water table.

Gloucester does not at this time allow for mitigative procedures to permit the draining of a perched water table. According to Enos (1991), the Health Board Agent, "the approach taken by the City is that water is water, and any water, drainable or not prohibits the use of subsurface wastewater disposal." Enos also pointed out that, in Gloucester, little to no permeable soils exist beneath the fragipan before reaching solid granite bedrock. Therefore, the model assumes that only houses connected to a POWTF located on appropriate soils could be built on soils with an underlying perched water table.

Results from soils developability model

The soils developability model, described above, was applied to the 46 different soil types present on the remaining parcels still potentially viable for development utilizing a POWTF (Table 23). Each soil type was evaluated for the cumulative affects of the constraints posed by slope, permeability, depth to bedrock, and seasonal high water table. A final development factor was established for each soil type based on the three different development scenarios. The first assumed that single family houses could be connected to a POWTF and the other two incorporated whether the land was to be used for the wastewater disposal from either a single family home or the entire output from a POWTF.

TABLE 23

GLOUCESTER SOIL CHARACTERISTICS AND ASSUMPTIONS

Soil	Slope %	Permeability in/hr	High Water feet (# monthes)	Developability Factor Sewer/ ISDS/ POWTF %
AnB	3-8	0.2-0.6	1.5-2.5 (4)	100/0/0
AnC	8-15	0.2-0.6	1.5-2.5 (4)	90/0/0
AnD	15-35	0.2-0.6	1.5-2.5 (4)	75/0/0
BuA	0-3	<0.2	1.0-3.0 (6)	100/0/0
CaB	3-8	6.0-20.0	>6.0	100/100/95
CbB	3-8	6.0-20.0	>6.0	100/100/95
CbC	8-15	6.0-20.0	>6.0	90/75/60
CcB	3-8	6.0-20.0	>6.0	100/100/95
CcC	8-15	6.0-20.0	>6.0	90/75/60
CcD	15-25	6.0-20.0	>6.0	85/65/0
CrC	3-15	0.6-6.0	>6.0	95/35/0*
CrD	15-35	0.6-6.0	>6.0	75/0/0*
De	0	>6.0	1.5-3.0 (5)	100/0/0
Fm	0	0.6-6.0	0-1.0 (12)	0/0/0
HfA	0-3	>20.0	>6.0	100/100/100
HfB	3-8	>20.0	>6.0	100/100/95
Iw	0	0.2-20.0	+1-0 (12)	0/0/0
Ma	0	<0.2	+1-.5 (11)	0/0/0
MmA	0-3	6.0-20.0	>6.0	100/100/100
MmB	3-8	6.0-20.0	>6.0	100/100/95
MsB	3-8	0.06-0.6	2.0-2.5 (4)	100/0/0
MsC	8-15	0.06-0.6	2.0-2.5 (4)	90/0/0
MsD	15-25	0.06-0.6	2.0-2.5 (4)	85/0/0
Pe	0	>20.0	.5-1.5 (9)	0/0/0
RlA	0-3	<0.2	0-1.5 (6)	0/0/0
RlB	3-8	<0.2	0-1.5 (6)	100/0/0
Rx	-	0	0	100/0/0
Sb	0	>6.0	+1-1 (12)	0/0/0
ScA	0-3	<0.2	0-1.0 (7)	0/0/0
SgB	3-8	0.06-0.2	1.5-3.0 (7)	100/0/0
ShC	8-15	0.06-0.2	1.5-3.0 (7)	90/0/0
SoB	3-8	0.06-0.2	1.5-3.0 (7)	100/0/0
SoC	8-15	0.06-0.2	1.5-3.0 (7)	90/0/0
SrA	0-3	2.0-20.0	1.5-3.0 (5)	100/0/0
SrB	3-8	2.0-20.0	1.5-3.0 (3)	100/0/0
Ss	0	>20.0	0-1.0 (12)	0/0/0
UAC	0	0	0	100/60/20
UD	0	0	0	100/60/20
Ur	0	0	0	100/60/20
WaA	0-3	>6.0	0-1.0 (6)	0/0/0
WaB	3-8	>6.0	0-1.0 (6)	0/0/0
We	0	6.0-20.0	0-1.5 (10)	0/0/0
Wh	0	<0.2	+1-.1 (10)	0/0/0
WrB	3-8	<0.2	1.5-3.0 (7)	100/0/0
WsB	3-8	<0.2	1.5-3.0 (7)	100/0/0
WsC	8-15	<0.2	1.5-3.0 (7)	90/0/0

* shallow depth to bedrock

A seasonal high water table is very common for the soils found throughout Gloucester due to the presence of fragipans, low lying areas, and the influence of tidal waters. Approximately 65 percent (30) of the soil types located on the development sites had a SHWT. In most cases, the presence of a SHWT also indicated soils with a permeability rate far less than required for properly leaching effluent into the ground. The water tables reached as high as one foot above the surface, with some persisting year round. Twelve soils with SHWT were indicated by the SCS to probably support wetland vegetation, therefore, resulting in a zero development factor for all scenarios. The other 18 soils possessing a SHWT would be developable only to houses with access to sewering since the high water level would prohibit proper subsurface disposal of septic wastes.

Shallow depth to bedrock only appeared in two soil types (CrC and CrD), found in the potential development sites. This information along with the other development factors cannot be interpreted until the actual acreages of each soil type are calculated within each parcel. Based on the final development factors for each scenario, the potential does exist for development to be greatly affected by the use of POWTFs. Twenty individual soils contain such constraints, which would render them completely undevelopable without access to a POWTF. On these soils, the development factor ranges between 75 to 100 percent given access to an appropriate location for a POWTF.

Only 12 soil types were calculated to be acceptable for a POWTF leaching field and 14 for ISDS, albeit at a higher developability rate. Overall the soils could be divided into three categories: soils entirely undevelopable, soils developable only with sewering, and soils developable under all scenarios. Only a few soils emerged with development factors lower than 75 percent but above 0 percent.

Application of Soils Developability Model to Parcels

The 29 parcels remaining within the constraints of this thesis were superimposed onto the SCS soil survey maps encompassing Gloucester. The soil types were divided into 11 categories with similar development ratios in order to simplify the measurement of soil areas within each parcel (Table 24). The area of each soil category was determined for each parcel and the corresponding net developable land was calculated by multiplying the land areas by the appropriate development factor for either ISDS or sewering (See Appendix 2). Land acreage appropriate for subsurface disposal of a POWTF is treated separately.

An accumulative breakdown of the soil types present on the 29 parcels is shown on Table 25. Overall, the undeveloped land within these parcels contains many soils constraints limiting development. Of the 11 development categories, four (1,2,6 and 7) represent approximately 95 percent of the total land area. Category one represents those soils assumed to be wetlands, and thus undevelopable

TABLE 24

DEVELOPMENT FACTOR CATEGORIES FOR SOIL TYPES

Category	Sewered	Sseptic	POWTF (%)	Soil Types
1	0	0	0	Fm, Iw, Ma, Pe, R1A, Sb, ScA, Ss, WaA, WaB, We, Wh
2	75	0	0	AnD, CrD
3	85	0	0	MsD
4	85	65	0	CcD
5	90	0	0	AnC, MsC, ShC, WsC, Soc
6	95	35	0	CrC
7	100	0	0	AnB, BuA, De, MsB, R1B, Rx, SgB, SoB, SrA, SrB, WrB, WsB
8	100	60	20	UAC, UD, Ur
9	90	75	60	CbC, CcC
10	100	100	95	CaB, CbB, CcB, HfB, MmB
11	100	100	100	HfA, MmA

TABLE 25

CUMULATIVE SOIL TYPES PRESENT ON UNDEVELOPED PARCELS

Category	Acres	Percent Total Acreage	Septic Acres	POWTF* Acres
1	232.3	16.23	0	0
2	622.2	43.51	0	0
3	0.5	0.03	0	0
4	2.3	0.16	1.15	0
5	15.2	1.06	0	0
6	240.4	16.81	84.14	0
7	258.2	18.05	0	0
8	25.2	1.76	15.12	5.04
9	14.7	1.02	11.03	8.82
10	18.1	1.26	18.10	17.20
11	0.8	.06	0.80	0.80
Total	1429.9		130.34	31.86

*Acres of land deemed appropriate for subsurface disposal.

under any scenario. Category 2 represents only two soil types (AnD and CrD), but encompasses over 43 percent of all the land available, and is considered to have many constraints to development. This soil category is characterized by steep slopes, perched water tables, and shallow depths to bedrock. Therefore, this category is only developable if sewering can be installed. The other two soil categories which make up a significant proportion of the available land (soil Type 6 and 7) both also have many constraints to development which would rely on subsurface disposal. This land, however is assumed appropriate for development which relied on sewering.

All total, only about 130 acres or nine percent of the land would support septic systems, while even more significantly, only about 32 acres or two percent of the total land area can be assumed to support POWTF waste disposal. Development in each of these parcels is clearly dependent on the availability of appropriate soils required for subsurface disposal of wastewater.

Variances in parcel land areas were found to exist between the original source of data from the Gloucester City Planning Office and the acreages derived from the SCS maps. In particular variances are evident for wetlands and total area acreages. The original wetland areas for each parcel were derived from the City's Conservation Commission Maps, and are considered to be only roughly accurate, requiring thorough site inspection and mapping prior to new development

(Gibbs, 1988). Total areas for the parcels randomly deviated by a few percent for most parcels, in all probability due to measurement error. However, six parcels deviated more than tne percent, with all but one calculated to be smaller than the information supplied by the City. Because all parcel areas were double checked for their total size, this variance is assumed to be due to the information supplied by the City Planning Office of Gloucester. Some form of error while recording the data, either the total area cited or plotting the parcel, is presumed to be the cause. This thesis henceforth assumes that the parcels plotted by the City Planning Office are correct and the total acreages cited have been a recording error. All data are analyzed according to the results from the parcels platted on the soils maps.

Potential Development

Applying the results from the soils developabiltiy model to each parcel is the last step to determime the potential development from the two different scenarios. The net developable land area and the potential development for each parcel are shown in Table 26. Included in this Table is the potential development with the use of municipal sewering, as well as with a POWTF to show the similar development rates. The location of each parcel along with developable acres and potential development can be found in Figure 19.

TABLE 26

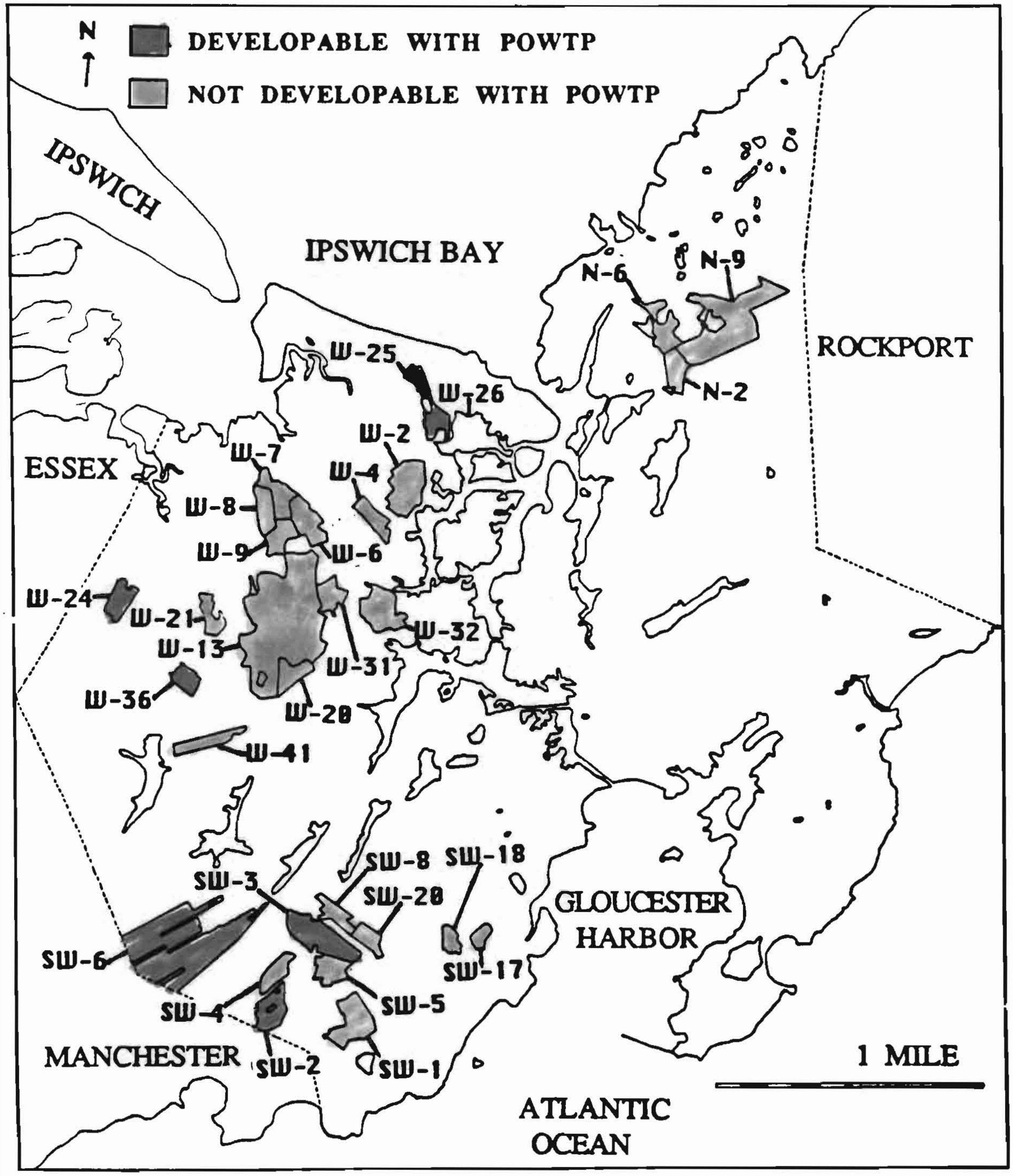
PARCEL DEVELOPMENT POTENTIAL

Parcel	Zoning	Total Size (acres)	Net Developable Land (acres)			Potential Development (units)		
			Sewer	ISDS*	POWTF**	Sewer	ISDS*	POWTF
N-2	R-2	26.7	15.2	0.6	0.0	24	1	0
N-6	R-2	32.8	24.2	0.4	0.0	38	0	0
N-9	R-RB	129.7	98.2	21.2	0.0	39	10	0
SW-1	R-3	49.4	40.5	11.0	0.0	129	44	0
SW-2	R-2	32.9	25.2	10.5	3.6	40	21	38
SW-3	R-2	50.6	24.5	4.2	3.8	39	8	37
	R-3	11.1	8.4	2.8	1.4	26	11	26
SW-4	R-2	22.7	12.9	0.3	0.0	20	0	0
SW-5	R-3	27.6	20.3	1.9	0.0	64	7	0
SW-6	I-2	210.0	142.9	15.3	7.6	228	30	222
SW-8	R-2	22.7	15.3	0.8	0.8	24	1	0
SW-17	R-3	11.5	9.7	1.3	0.0	31	5	0
SW-18	R-3	13.8	13.8	0.0	0.0	44	0	0
SW-20	R-3	18.6	12.2	0.0	0.0	39	0	0
W-2	R-2	47.1	42.0	11.7	0.0	67	23	0
	R-3	9.4	5.1	2.3	0.0	16	9	0
W-4	R-2	12.8	9.9	0.4	0.0	15	0	0
	R-3	11.0	9.3	1.7	0.0	29	6	0
W-6	R-2	36.9	32.7	0.0	0.0	52	0	0
W-7	R-2	31.2	28.4	1.6	0.0	45	3	0
W-8	R-2	27.6	24.7	1.1	0.0	39	2	0
W-9	R-2	25.5	19.2	1.4	0.0	30	2	0
W-13	R-2	263.6	179.8	4.1	0.0	287	8	0
	R-3	8.2	5.3	0.0	0.0	16	0	0
W-20	R-2	25.1	18.8	0.0	0.0	30	0	0
W-21	R-2	20.7	18.7	1.8	0.0	29	3	0
W-24	R-2	30.3	22.4	12.6	8.4	35	25	33
W-25	R-3	37.7	18.8	5.3	1.5	60	21	56
W-26	B-3	38.7	12.1	2.9	0.0	19	5	0
	R-3	25.8	5.9	2.8	0.0	18	11	0
W-31	R-3	23.9	22.4	1.2	0.0	71	4	0
W-32	R-3	48.5	38.5	4.9	0.0	123	19	0
W-36	R-3	18.7	11.9	3.8	3.6	38	15	34
W-41	R-2	27.1	26.1	0.8	0.0	41	1	0
Total		1429.9	1015.3	130.7	30.7	1845	295	446

* Assumes that roads can be located on land appropriate for sewering only.
** Soils appropriate for subsurface disposal from treatment plant.

FIGURE 19

PARCEL LOCATIONS EVALUATED FOR SOIL CONSTRAINTS



The potential development within the 1,429.9 acres is very low due to numerous soils constraints. Less than ten percent (130.7 acres) of the land is found to be developable with the use of ISDS. Within these scattered locations only about 295 housing units could be expected to be developed for an average of about one house per five acres. Similarly, the use of POWTFs is also severely limited due to soil constraints. An accumulative net total of only 30.7 acres was calculated to meet the criteria for subsurface disposal from a POWTF. The soil types were also only found on seven individual parcels, and the 0.8 acres found of parcel SW-8 is assumed to be below the minimum size required in order to develop a cost effective development utilizing this technology.

The six parcels possessing enough acreage of the appropriate soils to allow development with a POWTF are shown in Table 27. Increased development potential is portrayed in terms of the additional number of acres available and the corresponding housing units which could be built. The increase in developable land varied with each parcel, ranging between 7.3 acres for parcel W-24 to 124.5 acres for parcel SW-6. An accumulative increase of 188.6 acres, representing a possible 315 housing units, is evidenced between the six parcels.

Though city-wide the potential increased development may not at first appear all that large, the site specific impacts are significant. On average, developable land within just

TABLE 27

INCREASED DEVELOPMENT DUE TO POWTFs

Parcel	ISDS		POWTF*		Potential Increase	
	Acres	Units**	Acres	Units	Acres (%)	Units(%)
SW-2	12.6	21	25.2	38	12.6 (100)	17 (81)
SW-3	8.4	19	32.9	63	24.5 (292)	44 (231)
SW-6	18.4	30	142.9	222	124.5 (677)	192 (640)
W-24	15.1	25	22.4	33	7.3 (48)	8 (32)
W-25	6.4	21	18.8	56	12.4 (194)	35 (167)
W-36	4.6	15	11.9	34	7.3 (159)	19 (127)
Total	65.5	131	254.1	446	188.6 (288)	315 (314)

*Includes soils appropriate for disposal and land developable with sewering.

**Assumes that roads can be located on land appropriate for sewering only.

these six parcels increased by 288 percent with a corresponding increase in housing units by 314 percent. The smallest increase, in parcel W-24, still shows an increase in developable acreage of 48 percent. The greatest single increase was found in parcel SW-6 which evidenced an almost seven-fold increase in developable land. Based on this parcel's total size of 289 acres, it went from being only five percent developable to nearly 50 percent developable.

The regional proximity of the six parcels exacerbates the impacts of development due to POWTFs (See Figure 19, p. 194). All six are located in two regions of Gloucester, the west and southwestern, which are prone to future development. In particular, the three parcels located in the southerwestern region of the City (SW-2, SW-3, SW-6) are all located very close to one another. Thus, this region could be impacted by a unproportional amount of city-wide development.

Comparing the Gloucester build-out results to the two other similar studies previously conducted in Massachusetts, helps one to understand how the threats to open space from POWTF vary depending upon many site specific characteristics. The Hopkington and Lanesboro studies both resulted in increased development, albeit at a much reduced level than evidenced in Gloucester. The Hopkington study resulted in only a 24 percent increase in the number of housing units for those parcels large enough to accomodate a POWTF. The Lanesboro study resulted in an increase in the range of 100 percent. The major apparent difference between these study areas is their soil characteristics. Gloucester soils are generally very shallow with underlying bedrock often too close to allow for ISDS. Soils in the other two towns are not so poor for ISDS, thus the increased development due to POWTF is not so great. What this indicates is a casual correlation between soils which are not conducsive to ISDS and and increase in the possible development with the use of POWTF. This situation will arise with conditions such as found in Gloucester where a few isolated pockets of appropriate soils would allow for the subsurface disposal POWTF effluents.

CHAPTER VII

SUMMARY AND CONCLUSION

Summary

Privately-owned wastewater treatment facilities (POWTFs) are potentially an economical and technically sound system used for residential developments. Similar in design and function to a municipal sewage treatment plant, they can be sized to service any number of houses, with the costs being divided among the home owners. Effluent discharge from a POWTF, albeit in a localized high quantity, is far superior to the water quality effluent draining from a typical septic system. Hence, due to their recent cost-effectiveness, as well as documented capabilities for treating sewage, they are increasingly being proposed as a substitute for ISDS in large residential developments. In Massachusetts, their use has only been permitted for apartment complexes and condominiums. Mainly due to legal technicalities, they have so far been denied use for residential subdivisions. Many such proposals have already been attempted, and it will probably be only a matter of time before the problems are worked out and their use will be permitted for these developments too.

In Massachusetts, POWTFs have been used for over a decade for numerous applications. However, not until the housing boom of the mid-1980s was this technology considered cost-effective enough to be used in conjunction with residential subdivisions. Land prices were up, the economy was thriving, and the costs associated with sewage treatment became less of an influence on the marketability of buying or selling a house. Proposals for residential development which would utilize POWTFs were being submitted from one corner of the State to the other. It was not until this time that the public begin to consider the potential impacts that could result. State officials, environmental organizations, and municipal planning departments have expressed concern over the increase in proposals for residential subdivisions utilizing POWTFs. A flood of unforeseen problems are predicted, if development projects were permitted to fully utilize this innovative technology. A broad range of issues have been raised including environmental impacts, legal accountability, and land use implications.

One of the more far reaching concerns pertaining to POWTFs is their impact on open space. State-wide land development in the 1980s was already progressing at a record pace, and POWTFs could be used to allow development on land which otherwise would not have occurred. This situation exists because most municipalities in Massachusetts have relied on the Title V Regulations to restrict development. Title V is a body of regulations which sets the minimum standards for subsurface wastewater disposal. In many regions, site specific conditions such as slow soil permeability, shallow depth to bedrock, or water or steep slopes have restricted the use of ISDS. In these regions, there has typically been little impetus in the past to rezone the land based on what development is actually desired. The assumption has generally been, that regardless of the existing zoning, development would be limited by the restrictions on the use of ISDS. However, similar to a public sewer system, POWTFs provide a mechanism to develop land which could not accommodate ISDS. Instead, septic effluent can be piped off a property to a POWTF site, where conditions are appropriate for subsurface wastewater disposal.

In particular, open space within coastal regions appears to be threatened by the impacts of POWTFs. Even though it is already the most developed region of Massachusetts, development pressure in coastal regions continues to be unproportionally high. For example during a six year period in the 1980s, land development in coastal towns more than doubled development compared to that in non-coastal towns. However, because many of the prime development sites have long been used up, developers are increasingly proposing development on parcels which are barely appropriate for ISDS. Therefore, the impetus to utilize innovative sewage treatment technology, such as POWTFs, is great, and this has been found to be the case in numerous proposals for coastal communities.

The land-use implications involving POWTFs are a most significant long-term concern. Specifically, concerns focus on the changes in land-use resulting from potential POWTFs replacing traditional ISDS. Therefore, it was hypothesized that the use of privately owned sewage treatment facilities would lead to a greater loss of coastal open space compared to development which relied solely on ISDS.

Data to test this hypothesis were gathered by conducting two build-out scenarios in the coastal town of Gloucester, Massachusetts. The objective was to compare the land-use impacts of development utilizing POWTFs with that of traditional ISDS. Each build-out scenario was designed to display its maximum development potential, and its subsequent loss of open space. The data comprised for each build-out scenario encompassed all documented privately-owned undeveloped property within the city limits. If the development potential for the POWTF build-out scenario is greater than the ISDS build-out, then the hypothesis is accepted. If there was no difference between the two scenarios then the hypothesis is rejected.

Gloucester was chosen as the study site for various reasons. Gloucester fits the description of a coastal community, being practically surrounded by the ocean. The

City also was indicative of the extensive development pressure during the 1980s. City officials were flooded with development proposals of all types, including two proposals for large residential subdivisions utilizing POWTFs. Hence, this city, in particular, was highly concerned about the impacts of POWTFs, and readily offered assistance for this research by supplying city records, supplies, maps and professional advice on conducting such a study.

The other criteria which made Gloucester an appropriate study area is its relative quantity of undeveloped land, and the wide range of zoning regulations that it has in place. About 224 privately owned undeveloped parcels, totaling approximately 3,285 acres, were located in Gloucester. Parcel size ranged from many small parcels of only a few acres to the largest parcel which was just over 289 acres. Undeveloped land was located in all regions of the City. However, most of the large parcels were located in the western and southwestern portions of the City, far away from the central business district surrounding the commercial harbor. Parcel development was influenced by minimum lot size zoning, ranging from a high of eight houses per acre to a low of one house for every two acres. Some parcels were located within two different zoning districts and had to be treated separately.

In order to more accurately calculate build-out on the undeveloped parcels, a methodical series of development constraints were evaluated. The cost-effective size of a treatment plant, zoning, wetlands, parcel size, and numerous soil conditions were all evaluated. Individually, the constraints were often not severe, but when combined with the other criteria, development potentials were often drastically reduced.

The minimum sized POWTF considered to be cost-effective for development assumed a capacity of 10,000 gallons per day. Based on state regulations, this size treatment plant could accommodate up to 30 housing units with an average of three bedrooms each. This was a major limitation to development, because most of the undeveloped parcels were far too small to allow for a development of this magnitude. By incorporating zoning constraints, area for the treatment plant, and reserving 20 percent of each parcel for roads and other non-houselot services, only 42 parcels had the potential of being developed with POWTFs. However, because the minimum sized parcel for a 30 unit development was 9.2 acres, it included just over 55 percent of the available undeveloped land. Of these 42 parcels, 36 parcels totaling about 1,566 acres, were located in the western and southwestern regions of the City.

Three parcels totaling approximately 68 acres were discovered to be located within the City's municipal sewage treatment system. Thus, these parcels were deleted from the study because development on them would not be limited by sewage treatment options.

Wetland constraints were found to be a very significant barrier to development throughout most of Gloucester. Wetland impacts are magnified because of the 50-foot buffer restricting all development. Each of the remaining 39 parcels contained at least some wetlands or buffer areas, and two parcels were found to be composed entirely of wetlands. A total of 456 acres, or about 26 percent of all parcel land, were impacted from the presence of wetlands. Ten of the parcels were determined undevelopable with POWTFs due to the excessive quantity of wetlands.

To assess the constraints posed by soils on the remaining 29 parcels, a separate soils model was developed. The model incorporated soils data including slope, permeability and percolation rates, depth to bedrock, and the depth to the seasonal high water table on the 46 soil types found on the parcels. Gloucester was discovered to have very poor soil conditions, compounding the problem of limited space for development. Shallow depth to bedrock and steep slopes are very common and are characteristic in approximately 43 percent of the land area encompassed by the parcels. In those regions where soils were not limiting due to shallow bedrock, they are often of poor quality for proper infiltration of liquids from a subsurface disposal field. Only 12 soil types were found to be partially or totally acceptable for a POWTF leaching field, and 14 soil types for ISDS. This represented approximately 130 acres for ISDS and only 31 acres for a POWTF.

Appropriate soil types were not found to be evenly distributed within the development parcels leading to a wide range of developability patterns from one parcel to another. Seven of the parcels did not have the soil characteristics to accommodate ISDS. The remaining 22 parcels could facilitate varying degrees of ISDS use, and only six had the appropriate soil types and quantities to allow for development with a POWTF. Maximum development potential under the ISDS scenario could allow for a possible 295 housing units. If POWTFs were utilized on the six potential parcels, and ISDSs are utilized on the remainder, a total of approximately 610 housing units could be built. This represents an almost 100 percent increase in overall potential housing on these 29 parcels. Evaluating the six possible POWTF parcels as a subgroup, there is a 314 percent increase in potential housing development. It was also discovered that the six parcels were all within two rather confined regions of the City, thus possibly elevating the localized impacts on open space, rather than impacting the City as whole. These results allow the hypothesis of an increasing loss of open space with the utilization of POWTFs to be accepted.

Conclusions

The testing of the major hypothesis, in addition to critiquing related assumptions and minor questions, allows this study to evaluate the land-use impacts of POWTFs. Due to site specific environmental and legal constraints involving residential development and wastewater disposal practices, most of the conclusions based on this study are directed specifically at Gloucester, Massachusetts. However, many of the findings, methodology, and general assumptions would be valuable for approaching related questions in other communities.

Determining whether or not there was a problem with the availability and loss of coastal open space was a necessary question before an evaluation of the impacts of new sewage treatment technology could proceed. Answering this question tends to be subjective because land is continually being developed, and there is no true definition of what is considered over development. However, the findings of this thesis do conclude, that both in terms of land consumption and public perception, there is indeed a major problem with the availability and loss of coastal open space. This conclusion is supported by both the historical perspective of land-use, in Massachusetts, and by increased efforts by governmental and non-governmental organizations to protect the limited areas of undeveloped coastal property remaining throughout the State.

Land development and public usage was found to be high throughout all of Massachusetts. In particular, coastal communities were undergoing an unproportionally high rate of development, and coastal amenities were attracting more people than often could be accommodated. Coastal towns already possessed a large share of the State's population and developed land, but during the 1980s development in these areas was found to almost double the rate of development compared to that of inland communities.

The public perception of state-wide development became very critical. Public criticism fueled efforts to curb development in many areas, until a proper census of the impacts could be compiled. Hence, the strong efforts by state and citizen groups to protect open space state-wide. Regional planning and community Master Plans were actively reassessed, resulting in many programs whose purpose was specifically intended to halt development in selective regions of the State. Numerous coastal programs in particular were developed to increase the percentage of protected open space in these areas. It was soon recognized that coastal property was rapidly being developed and relatively little was left for preservation.

The situation in Gloucester helps support the conclusion about the recent problems relating to coastal open space. Gloucester has unique coastal characteristics such as an extensive coastline, dozens of beaches, and panoramic views, all within a commuting distance to high paying employment in the Boston area. These attributes, along with the existence of many developable parcels of land, lead to the recent development boom which affected the City during the 1980s. Residential subdivision proposals were being submitted to the City at an alarming rate. The

City newspaper had almost continuous coverage of the impacts development was having throughout the area. Grass root organizations developed to protect the unique character, which was perceived to be threatened predominantly by residential development. Concern grew toward the regulatory and technical mechanisms involving subsurface wastewater disposal and how they affected open space.

This thesis's main focus was to test the hypothesis that POWTFs could potentially lead to an increase in the development of coastal open space, when compared to the use of traditional ISDS. This hypothesis is accepted based on both the site specific case study conducted for Gloucester, and ancillary information pertaining to the use of Title V subsurface disposal regulations.

The municipal use of Title V Regulations are what allows this study to make state-wide conclusions about the impacts of POWTFs on coastal open space. Many towns continue to estimate development solely based on ISDS, even with the prospects of new technologies which could override the constraints which preempted the use of ISDS. Numerous references were found indicating that like Gloucester, other cities and towns have been indirectly relying on the restrictive nature of Title V to act as a growth control tool. In Gloucester, many rural areas were zoned high density which predate most wetland regulations, strict enforcement of ISDS regulations, and concern for the preservation of open space. Thus, these areas which contained innumerable constraints to the use of ISDS have up until relatively recently never been considered all that developable. Public sewering was never expected to reach these regions, and because the use of ISDS was severely constrained due to environmental constraints, there was little concern to change to large lot zoning. Hence, these relatively high density zoned areas represented a land-use problem waiting for a technical solution to handle sewage treatment.

As hypothesized, the build-out scenario in Gloucester supplies the data to conclude that POWTFs can indeed allow for increased development, along with the subsequent loss of open space compared to the use of ISDS. It also shows that POWTFs do in fact overcome the barriers to rural development posed by Title V Regulations. They allow for development similar to public sewering, thus avoiding subsurface disposal requirements such as percolation tests and restrictive locational setback distances for the siting of ISDS. Differential development is chiefly due to the fact that Gloucester soils are relatively poor with small pockets of good soils appropriate for subsurface disposal. Effluent from a treatment plant can be located on the good soils and connected sewer pipes can allow for development on much of the other land which otherwise would not accommodate ISDS.

The final comparison evaluated 29 of the larger parcels representing just under one third of the City's remaining developable land. According to the described methodology, only six of these parcels met the regulatory and physical criteria required to support a POWTF. Though this represents a rather limited overall city-wide use, the increase in potential development could be as high as 315 additional housing units on just these six parcels. This increase in housing, based on POWTFs, would utilize about 188 acres or five percent of developable land which otherwise could not have been developed with ISDS.

The city-wide land-use impacts from the use of POWTFs represent only a limited quantity of overall land in Gloucester, but the site specific impacts could be relatively severe. The cumulative results for the six parcels indicated a potential increase of 314 percent in housing development, with a corresponding increase of 288 percent in property to meet zoning requirements. The parcel with the greatest differential of development was found to potentially accommodate about 142 acres for development, up from only about 18 acres if only ISDS were utilized. Thus, in this case, the new technology results in the difference between very low density rural development, and a relatively high density residential subdivision utilizing much of the available property. The other five parcels exhibited similar, albeit lower rates of increased development, but in each case they could significantly affect the quantity of available open space following full development. Therefore, instead of permitting a small incremental increase in development, POWTFs under this build-out scenario in

Gloucester could allow for much more intense development in a few site specific parcels.

Local land-use impacts on a regional scale were evidenced once the parcels were plotted on a map. Similar to the visually non-random location of undeveloped land in Gloucester, potential sites for POWTFs were centralized in the southwestern and western portions of the City. Large tracts of undeveloped land remain in these portions of the City, because there exists large environmental constraints which several restrict the use of ISDS. Some regions of the City which are only partially developable with ISDS are potentially fully developable in a few of the larger parcels with the use of POWTFs. Using this technology development is chiefly limited by only wetlands and zoning restrictions. Therefore, if development proceeded with full utilization of POWTFs, these areas which previously were deemed rather undevelopable, could be impacted with a half dozen subdivisions totally out of character with limited development in adjacent land.

The data used to support the major hypothesis of this study were based upon the methodology which portrayed a maximum level of development. However, alternative levels of development must also be considered when evaluating POWTFs. In some cases, the high economic return on an exclusive large lot development can more than offset any loss of revenue from building more, less expensive houses on the same property. In another case, a POWTF could be used to allow for clustered development, grouping the development in one area of a parcel, and leaving the remainder as open space. People are willing to pay a premium for more undeveloped and open space atmosphere in their neighborhood.

With no residential subdivisions actually developed utilizing POWTFs, it is difficult to predict if they would only be used for a maximum level of development. Conclusions can only be based on the few residential development proposals in Gloucester and other communities which had hoped to use POWTFs. In most of these cases, especially in Gloucester, POWTFs were proposed to allow for a dramatically different level of development than could be facilitated utilizing ISDS. Thus, strong incentives exist to attempt to utilize this technology when the existing conditions are conducive to only limited development with ISDS.

The utilization of a build-out scenario in Gloucester was found to be an appropriate methodology to exemplify potential development patterns. The general conclusion that POWTFs possess the potential to allow for increased development can be applied to other communities, but site specific characteristics will dictate what those impacts will be. Gloucester has many social and physical characteristics which are conducive to the utilization of POWTFs. A commuting distance to Boston, desires to live in a coastal town, and a relative rural feeling in the less developed portions of the City act to attract high-paying home owners. An abundance of undeveloped property possessing only a limited quantity of percable soils limits the use of ISDS. The combination of strong demand to develop, and the restrictive soil constraints make Gloucester a prime community to have land-use impacts from POWTF technology. By incorporating similar characteristics and a similar methodology, the state-wide predictions of land-use impacts of POWTFs could be accomplished. It is generally known that many similar characteristics do exist state-wide, and where they do, POWTFs can pose threats to open space.

A major point raised by this thesis is the strong dependence of a build out scenario on assumptions ranging from soil suitability to the cost effectiveness of POWTFs verses ISDS. Physical and regulatory constraints between the two technologies are not similar and only limited information is available about the realistic application of POWTFs. Subtle changes in any one of the assumptions on which the methodology is based could lead to significantly different results. Assumptions in this thesis were based upon the best available information and were meant to anticipate, as close as possible, development which might occur. As described above, actual development proposals can vary significantly, based strictly on market demands and not physical limitations.

Another important conclusion of this thesis is that prime land for development, in Gloucester, and other coastal areas as a whole is diminishing. The corollary is that the reliance on alternative sewage disposal will be increasing as development of marginal land becomes more lucrative. Development will continue to become less dependent on the traditional septic system. New technologies will be developed which can pose similar threats to open space, as do POWTFs at the present time.

Innovative sewage treatment technologies such as POWTFs do possess positive attributes which must be commended. They can be used to remediate problem areas, where septic systems are failing and posing threats to the environmental and public health. City governments burdened with supplying expensive municipal sewering can save tax dollars by allowing private developers to absorb the costs of sewage treatment for new development. Also, with the appropriate subdivision regulations, POWTFs can be used prevent generic total land utilization development by providing incentives for clustered development.

The current recession in Massachusetts has allowed for break in the development boom of the 1980s that can be used to access the land-use impacts of new sewage treatment technology and its impacts on open space. Public officials should continue to solicit local input on developing new zoning regulations, if it is found that these new technologies can allow for development to adversely alter the desired and/or previously expected character of that development. Thus, Gloucester and municipalities throughout

Massachusetts need to choose what direction they want growth to continue with the knowledge that new technologies will be developed which can circumvent the indirect growth controls presently upheld with limits to the use of septic systems. Development will occur and towns must assume that a property that is legally zoned to prevent development, could potentially be developed to its legal limit due to a simple technical innovation, as well as changes in the development market.

Appendix 1

NUMBER OF MASSACHUSETTS SPECIES ON STATE AND FEDERAL ENDANGERED LISTS

	Endangered	Threatened	Special Concern
Mammals	7 (all Fed.)	0	5
Birds	9 (4 Fed.)	7 (1 Fed.)	15
Reptiles	6 (4 Fed.)	5 (2 Fed.)	3
Amphibians	0	2	6
Fishes	3 (1 Fed.)	2	3
Invertebrates	21	13	55
Plants	81 (2 Fed.)	59	55
Total	127 (18 Fed.)	88 (3 Fed.)	142

Species listed on both Massachusetts and Federal Endangered (E) and Threatened (T) Lists

Mammals:
- Indiana Bat (E)
- Sperm Whale (E)
- Fin Whale (E)
- Sei Whale (E)
- Humpback Whale (E)
- Atlantic Right Whale (E)
- Blue Whale (E)

Birds:
- Bald Eagle (E)
- Peregrine Falcon (E)*
- Piping Plover (E)*
- Eskimo Curlew (E)
- Roseate Tern (E)*

Reptiles:
- Plymouth Red-bellied Turtle (E)*
- Hawksbill Turtle (E)
- Loggerhead Turtle (T)
- Kemps Ridley Turtle (E)
- Leatherback Turtle (T)
- Green Turtle (T)

Fishes:
- Shortnose Sturgeon (E)*

Plants:
- Small Whorled Pogonia (E)*
- Sandplain Gerardia (E)*

* Breeds in Massachusetts

Source: Massachusetts Natural Heritage and Endangered Species Program. Feb. 1988.

APPENDIX 2

T= Total Acres in Category
SP= Developable Acres with ISDS
SW= Developable Acres with POWTF

Parcel	Zoning	Category 1 (acres) T	SP	SW	Category 2 (acres) T	SP	SW	Category 3 (acres) T	SP	SW	Category 4 (acres) T	SP	SW
N- 2	R-2	8.4	0.0	0.0	11.8	0.0	8.9	0.5	0.0	0.4	0.0	0.0	0.0
N- 6	R-2	1.4	0.0	0.0	27.4	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0
N- 9	R-3	21.0	0.0	0.0	30.9	0.0	23.2	0.0	0.0	0.0	0.0	0.0	0.0
SW- 1	I-2	0.0	0.0	0.0	7.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0
SW- 2	R-2	5.2	0.0	0.0	10.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0
SW- 3	R-2	20.1	0.0	0.0	24.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	1.7	0.0	0.0	3.3	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
SW- 4	R-2	6.2	0.0	0.0	15.2	0.0	11.4	0.0	0.0	0.0	0.0	0.0	0.0
SW- 5	R-3	2.8	0.0	0.0	16.2	0.0	12.2	0.0	0.0	0.0	0.0	0.0	0.0
SW- 6	I-2	27.9	0.0	0.0	139.1	0.0	104.3	0.0	0.0	0.0	0.0	0.0	0.0
SW- 8	R-2	4.8	0.0	0.0	10.3	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0
SW-17	R-3	0.0	0.0	0.0	6.5	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0
SW-18	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SW-20	R-3	2.6	0.0	0.0	15.1	0.0	11.3	0.0	0.0	0.0	0.0	0.0	0.0
W- 2	R-2	0.0	0.0	0.0	13.7	0.0	10.3	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W- 4	R-2	0.0	0.0	0.0	11.8	0.0	8.9	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	6.2	0.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
W- 6	R-2	2.5	0.0	0.0	6.8	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
W- 7	R-2	1.2	0.0	0.0	5.7	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0
W- 8	R-2	1.3	0.0	0.0	5.6	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0
W- 9	R-2	5.4	0.0	0.0	2.7	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
W-13	R-2	47.0	0.0	0.0	143.7	0.0	107.9	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	1.8	0.0	0.0	4.3	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
W-20	R-2	0.0	0.0	0.0	25.1	0.0	18.8	0.0	0.0	0.0	0.0	0.0	0.0
W-21	R-2	0.0	0.0	0.0	6.8	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
W-24	R-2	7.1	0.0	0.0	1.2	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
W-25	R-3	19.0	0.0	0.0	7.5	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0
W-26	B-3	24.7	0.0	0.0	5.8	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	13.4	0.0	0.0	4.3	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
W-31	R-3	1.2	0.0	0.0	8.2	0.0	6.2	0.0	0.0	0.0	2.3	1.2	2.0
W-32	R-3	0.9	0.0	0.0	33.7	0.0	25.3	0.0	0.0	0.0	0.0	0.0	0.0
W-36	R-3	4.7	0.0	0.0	8.6	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0
W-41	R-2	0.0	0.0	0.0	3.7	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
Total		232.3	0.0	0.0	622.2	0.0	467.0	0.5	0.0	0.4	2.3	1.2	2.0

APPENDIX 2

T=Total Acres in Category
SP=Developable Acres with ISDS
SW=Developable Acres with POWTF

Parcel	Zoning	Category 5			Category 6			Category 7			Category8		
		T	SP	SW	T	SP	SW	T	SP	SW	T	SP	SW
N- 2	R-2	0.0	0.0	0.0	1.6	0.6	1.5	4.4	0.0	4.4	0.0	0.0	0.0
N- 6	R-2	2.7	0.0	2.4	1.1	0.4	1.0	0.2	0.0	0.2	0.0	0.0	0.0
N- 9	R-3	2.1	0.0	2.3	60.5	21.2	57.5	15.2	0.0	15.2	0.0	0.0	0.0
SW- 1	I-2	0.0	0.0	0.0	29.0	10.2	21.8	12.4	0.0	12.4	0.2	0.1	0.2
SW- 2	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	17.1	10.3	17.1
SW- 3	R-2	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	2.3	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	3.7	1.3	3.5	0.9	0.0	0.9	0.0	0.0	0.0
SW- 4	R-2	0.4	0.0	0.4	0.5	0.2	0.5	0.2	0.0	0.2	0.2	0.1	0.2
SW- 5	R-3	1.8	0.0	1.6	5.5	1.9	5.2	1.3	0.0	1.3	0.0	0.0	0.0
SW- 6	I-2	5.0	0.0	4.5	16.9	5.9	6.1	8.6	0.0	8.6	0.0	0.0	0.0
SW- 8	R-2	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	6.8	0.0	0.0	0.0
SW-17	R-3	0.0	0.0	0.0	3.6	1.3	3.4	1.4	0.0	1.4	0.0	0.0	0.0
SW-18	R-3	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0	13.8	0.0	0.0	0.0
SW-20	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.9	0.0	0.0	0.0
W- 2	R-2	0.0	0.0	0.0	33.3	11.7	31.6	0.1	0.0	0.1	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	6.5	2.3	2.2	2.9	0.0	2.9	0.0	0.0	0.0
W- 4	R-2	0.0	0.0	0.0	1.0	0.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	4.8	1.7	4.6	0.0	0.0	0.0	0.0	0.0	0.0
W- 6	R-2	0.0	0.0	0.0	0.0	0.0	0.0	27.6	0.0	27.6	0.0	0.0	0.0
W- 7	R-2	0.0	0.0	0.0	4.7	1.6	4.5	19.6	0.0	19.6	0.0	0.0	0.0
W- 8	R-2	0.0	0.0	0.0	3.1	1.1	2.9	17.6	0.0	17.6	0.0	0.0	0.0
W- 9	R-2	0.0	0.0	0.0	4.0	1.4	3.8	13.4	0.0	13.4	0.0	0.0	0.0
W-13	R-2	3.2	0.0	2.9	11.6	4.1	11.0	58.1	0.0	58.1	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	2.1	0.0	0.0	0.0
W-20	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W-21	R-2	0.0	0.0	0.0	5.1	1.8	4.8	8.8	0.0	8.8	0.0	0.0	0.0
W-24	R-2	0.0	0.0	0.0	9.6	3.4	9.1	2.6	0.0	2.6	0.0	0.0	0.0
W-25	R-3	0.0	0.0	0.0	1.9	0.7	1.8	1.6	0.0	1.6	7.7	4.6	7.7
W-26	B-3	0.0	0.0	0.0	8.2	2.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0
	R-3	0.0	0.0	0.0	8.1	2.8	2.7	0.0	0.0	0.0	0.0	0.0	0.0
W-31	R-3	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.0	12.2	0.0	0.0	0.0
W-32	R-3	0.0	0.0	0.0	13.9	4.9	13.2	0.0	0.0	0.0	0.0	0.0	0.0
W-36	R-3	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6	0.0	0.0	0.0
W-41	R-2	0.0	0.0	0.0	2.2	0.8	2.1	21.2	0.0	21.2	0.0	0.0	0.0
Total		15.2	0.0	14.1	240.4	84.6	213.5	258.2	0.0	258.2	25.2	15.0	25.2

APPENDIX 2

T= Total Acres in Category
SP= Developable Acres with ISDS
SW= Developable Acres with POWTF

Parcel	Zoning	Category 9			Category 10			Category 11			Category Total		
		T	SP	SW	T	SP	SW	T	SP	SW	T	SP	SW
N- 2	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.7	0.6	15.2
N- 6	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.8	0.4	24.2
N- 9	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	129.7	21.2	98.2
SW- 1	I-2	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	49.4	11.0	40.5
SW- 2	R-2	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	32.9	10.5	25.2
SW- 3	R-2	0.0	0.0	0.0	4.2	4.2	4.2	0.0	0.0	0.0	50.6	4.2	24.5
	R-3	0.0	0.0	0.0	1.5	1.5	1.5	0.0	0.0	0.0	11.1	2.8	8.4
SW- 4	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.7	0.3	12.9
SW- 5	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	1.9	20.3
SW- 6	I-2	12.2	9.1	12.2	0.3	0.3	0.3	0.0	0.0	0.0	210.0	15.3	142.9
SW- 8	R-2	0.0	0.0	0.0	0.8	0.8	0.8	0.0	0.0	0.0	22.7	0.8	15.3
SW-17	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	1.3	9.7
SW-18	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0	13.8
SW-20	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.6	0.0	12.2
W- 2	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.1	11.7	42.0
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	2.3	5.1
W- 4	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.4	9.9
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	1.7	9.3
W- 6	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.9	0.0	32.7
W- 7	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.2	1.6	28.4
W- 8	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	1.1	24.7
W- 9	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5	1.4	19.2
W-13	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	263.6	4.1	179.8
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	5.3
W-20	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.1	0.0	18.8
W-21	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	1.8	18.7
W-24	R-2	2.5	1.9	2.5	7.3	7.3	7.3	0.0	0.0	0.0	30.3	12.6	22.4
W-25	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.7	5.3	18.8
W-26	B-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.7	2.9	12.1
	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.8	2.8	5.9
W-31	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.9	1.2	22.4
W-32	R-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.5	4.9	38.5
W-36	R-3	0.0	0.0	0.0	3.8	3.8	3.8	0.0	0.0	0.0	18.7	3.8	11.9
W-41	R-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	0.8	26.1
Total		14.7	11.0	14.7	18.1	18.1	18.1	0.8	0.8	0.8	1429.9	130.7	1015.3

BIBLIOGRAPHY

Almada, Michael. Improved Wastewater Management. Testimony regarding Massachusetts House Bill #6122. October 30, 1987.

Alford, Michael, R. and James F. Hudson. Improving Environmental Quality Through the use of Local Ordinances and Regulations. EPA Contract No. 68-01-3231. March, 1979.

Amato, Peter W., and Harrison D. Goehring. Small Scale Waste Management Systems: Land Use and Policy Implications in a Three County Wisconsin Area. University of Wisconsin Extension, Small Scale Waste Management Project. April 1, 1974.

Annis, Tammy. "Revised Plan Set for Golf Course." Gloucester Daily Times. p.1 c.2. January 20, 1990.

Autotrol Corporation. Design Manual: Wastewater Treatment Systems. Bio-Systems Division, Product Literature. 1978.

Bates, Roland. Originally quoted by Susan Flynn in "Plan outlined for project off Essex Avenue." The Gloucester Daily Times. p. 1, c. 3. June 23, 1989.

Benes, Marcia. Letter from Marcia Benes, President of Massachusetts Association of Home Builders, to Massachusetts Department of Environmental Quality Engineering. Subject: Privately Owned Wastewater Treatment Plants. August 26, 1987.

Binkley C. et. al. Interceptor Sewers and Urban Sprawl. Lexington Books, D.C. Heath and Company. 1975.

Blaustein, Joan. "Balancing the Need for Open Space Protection with Rising Land Costs. Update 2000, A Progress Report on Metroplan 2000. Vol. 1, No. 1,. 1988.

Bliven, Steven. The Massachusetts Program for Identification, Designation, and Protection of Critical Areas. Massachusetts Coastal Zone Management, Publication # 15004-111-250-9-87-C.R. 1987.

Blomberg, G.D. "Coastal Amenities and Values: Some Pervasive Perceptions Expressed in Literature". Coastal Zone Management Journal. Vol. 10, No. 1/2. 1982.

Boston Redevelopment Corp. v. Commonwealth of Massachusetts. 393 N.E. 2d 256, 367. 1979.

Brautigam, Steve and Renee L. Robin. The Way to the Sea. Massachusetts Coastal Zone Management, Boston, Massachusetts. 1985.

Britcha, Donald. "Pollution Threatens many Shellfish Flats." Gloucester Daily Times. p.1 c.2. September 10, 1988.

Brichta, Donald. "Private Sewerage Plants Debated at Statehouse". Gloucester Daily Times. p. 1, c. 1. October 30, 1988.

Brown, Gardner M. Jr. and Henry O. Pollakowski. "Economic Valuation of Shoreline". Review of Economics and Statistics. pp 272-278, Vol. 59. 1977.

Brown, Peter. Assistant Planner, Gloucester Planning Department, Gloucester, Massachusetts. Personal Communication. January 7, 1989.

Brown, Rodney. Director, MDEM Coastal Aquisition. Personal Interview. October 3, 1988.

Burrington, Steve. Higher Standards and Higher Stakes: Privately-Owned Sewage Treatment Plants in New England . Residential Developments. Conservation Law Foundation of New England Inc., Boston, MA.. 1988.

Burrington, S.H. and M. Rockefeller. Letter to Citezens Advisory Committee for GEIR on POWTFs. April 12, 1988.

Burrington, S.H., B. Kern, M. Rockefeller, J. Shope, C. Simmons and P. Chapan. Letter to Citizens Advisory Committee for GEIR on POWTFs. April 7, 1989.

Business Week. "More Elbow Room for the Electronic Industry". p. 13. March, 1980.

Buzzards Bay Project. Annual Report. EPA Contract # 68-03 -3319. 1987.

Buzzards Bay Project. Fact Sheet # 1. "Bacterial Contamination of Shellfish". 1989.

Canter, L.W. and Robert C. Knox. Septic Tank Systems Effects on Ground Water Quality. Lewis Publishers Inc., Chelsea, Michigan. 1985.

Caputo, D.F. Open Space Pays: The Socioeconomics of Open Space Preservation. Green Acres Program, New Jersey Department of Environmental Protection. 1979.

Castle View Environmental Evaluation. Report Submitted to Gloucester Planning Department. Gloucester, Massachusetts. 1987.

Clark Engineering, Inc. Privately Owned Treatment Facility Growth Impact Study, Town of Lanesborough, Berkshire County, Massachusetts. July 20, 1989.

"Coles Island Environmental Impact Evaluation". Essex Bay Estates Limited Partnership. Submitted to: City of Gloucester Planning Board. October, 1988.

Collins V. City of Bloomington. Bloomington Minn. 5, 13, 246, N.W. 2d19, 23-24. 1976.

Correl, M.R., J. H. Lillydahl and L.D. Singell. "The Effects of Green Belts on residential property values: some findings on the political economy of open space." Land Economics. Vol. 54, pp. 207-217. 1978.

Deese, P.L and James F. Hudson. Planning Wastewater Management Facilities for Small Communities. U.S. EPA. August, 1980.

Dobie, Keith. Mahoney Associates, Inc., Personal Interview Conducted by Charolette Young. Small Privately Owned Wastewater Treatment Plants and Their Potential Use in Massachusetts Single Family Home Developments. Masters Thesis. Urban and Environmental Policy and Civil Engineering. April 25, 1988.

Dumonoski, Diane. "State Losing its Wetlands in Small but Vital Pieces." The Boston Globe. p. 1., c. 1. January 26, 1989.

Enos, Robert. Board of Health Agent, Gloucester, Massachusetts. Personal Communication. December 9, 1991.

Environmental Outlook. "1987: The Year of the Environment, Governor Signs Three Environmental Bills into Law." January, 1988.

Euclid V. Amber Realty Co. 272 U.S. 365, 390-396. 1926.

Evans, A.W. The Economics of Residential Location. Macmillian Publishing, London. 1973.

Foster, Richard. MEPA Unit, Massachusetts Executive Office of Environmental Affairs. Personal Interview. December 22, 1988.

Frankel, M. Law of the Seashore, Waters: Maine and Massachusetts. 1969.

Gibbs, Glen. Director of Community Planning, Gloucester, Massachusetts. Personal Communication. January 11, 1988.

Gloucester Board of Health. Ordinance Prohibiting the Construction of Small Wastewater Treatment Plants. May 2, 1988.

Gloucester Conservation Commission. "Open Space and Recreation Plan". Gloucester, Massachusetts. 1984.

Gloucester Community Planning Department. "Identification Project of Undeveloped Parcels". Gloucester, Massachusetts 1989.

Gloucester Daily Times. Staff Report. "Housing Developer Sues City." p.1 c.2. January 12, 1988.

Gloucester General Plan. Gloucester Plannning Department. Gloucester, Massachusetts. 1980.

Gloucester Master Plan. Gloucester Planning Department. Gloucester, Massachusetts. 1990.

Gloucester Open Space and Recreation Plan. Gloucester Planning Department, Gloucester, Massachusetts. 1990.

Gloucester Planning Board. New Subdivision Amendments. Gloucester, Massachusetts. Enacted February 9, 1987a.

Gloucester Planning Board. Vote passed to Dissaprove the Coles Island Subdivision Plan. Gloucester, Massachusetts. March 16, 1987b.

Gloucester Planning Department. Results and Reccomendations of Potential Gloucester Development Scenario. 1988.

Goetz, J.P., and M. D. Lecompte. Ethnography and Qualitative Design in Educational Research. Academic Press, Orlando, Florida. 1984.

Grabler, Peter H.F. "The Law of the Coast in a Clamshell, Part VI: The Massachusetts Approach". Shore and Beach. January, 1982.

Greenbaum, D.S. and Arleen O'Donnell. "Losing Ground: the Case for Land Conservation in Massachusetts". Massachusetts Audubon Society. October, 1987.

Greenbaum, D.S. "Massachusetts Audubon Call for Moratorium on Private Sewage Treatment Plants." Massachusetts Audubon Society Press Release. March 10, 1988.

Gross and Thrasher. Causes, Correction and Prevention of Septic Tank Absorption System Malfunction. 1984.

Hall, P. et al. The Containment of Urban England. Allen & Unwin, London. 1973.

Hammer, T.R., R.E. Coughlin and E.T. Horn IV. "The Effect of a Large Park on Real Estate Value". Journal of the American Institute of Planners. July, 1974.

Hayes Engineering Inc., Soil Survey Report: Coles Island Estates,. Gloucester, Massachusetts. July 24, 1987.

Healy, Robert G. and Jeffry A. Zinn. "Environmental and Development Conflicts in Coastal Zone Management." Journal of American Planning Association. Summer, 1985

Herr, Philip S. and Phyllis Robinson. Analysis of Land Consumption, 1981-1986". Prepared for the Massachusetts Audubon Society. July, 1987.

Hoxie, Donald C., Russel G. Martin and David P. Rocque. A Numerical Classification System to Determine Overall Site Suitibility for Subsurface Wastewater Disposal. 1988.

Hoyte, James S. Secretary, Massachusetts Executive Office of Environmental Affairs. As quoted in Gloucester Daily Times. p. 1, col. 1. August 24, 1988a.

Hoyte, James S. Secretary, Massachusetts Executive Office of Environmental Affairs. Environmental Notification Form for the Essex Bay Estates at Coles Island. December 14, 1988b.

Hruby, Thomas. "The Shellfish Resource in a Polluted Tidal Inlet." Environmental Conservation. Vol. 8, No. 2. 1981.

ICF Inc. Draft Generic Environmental Impact Report on Privately Owned Sewage Treatment Facilities. Sponsored by the Massachusetts Executive Offices of Environmental Affairs; Communities and Development; and Economic Affairs. May, 1990.

Keene, John C. "Differential Accessment and the Preservation of Open Space." Urban Law Annual. vol. 14, pp. 11-46. 1977.

Kellog, Charles E. Soil Surveys and Land Use Planning. Soil Science Society of America and American Society of Agronomy. p. 1. 1966.

Kelly, Eric Damian. "Piping Growth: The Law, Economics, and Equity of Water Connection Policies." Land Use Law and Zoning Digest. vol. 36 pp. 3-8. 1976.

Kidder, L.H., and Fine, M. Qualitative and Quantitative Methods: When Stories Converge. In M.M. Mark and R.L. Shotland (eds.). Multiple Methods in Program Evaluation and New Directions for Program Evaluation. no. 35. San Francisco, Jossey-Bass. 1987.

Kirby, Russel. Massachusetts DEQE Public Hearing on Groundwater Discharge Permit for the Willis Hills Subdivision. August 4, 1987.

Kirk, Bill. "Developer Deals Worry Residents." Gloucester Daily Times. p.1, c.2. November 10, 1989.

Kline, Elizabeth. Secretary, Massachusetts Ececutive Office Of Environmental Affairs. Legislative Testimony. "Acts Relative to the Aplication of Small Privately Owned Wastewater Treatment Facilities." March 9, 1988.

Kuehn, R. Jr. and Robert Engler. Letter to the GEIR Citizens Advisory Committee. Subject: Hopkington "Build-Out " Study. January 19, 1988.

Kuehn, R. Jr. and Robert Engler. Letter to the Citizens Advisory Committee on POWTFs. April, 1989.

Lang, Jill. "Development: Right or Privelege." Gloucester Daily Times. p.1, c.1. March 24, 1988.

Leahy, Christopher W. "Edens End: The Case for Ecological Protection in Massachusetts." Conservation Department, Massachusetts Audubon Society. 1988.

Little, C.E. Challenge of the Land. Reprinted in Open Space Pays, Green Acres Program. N.J. Depart. of Environmental Protection. 1979.

Lund, Ken. Understanding Septic Systems. Massachusetts Rural Community Assistance Program. 1988.

Lurie, Carol. Memorandum to Martin Pillsbury, Director, Metropolitan Area Planning Council. October 28, 1988.

MacConnell, William P. <u>Remote Sinsing: Twenty Years of Change in Massachusetts 1951/52 - 1971/72</u>." University of Massachusetts, Amherst Agricultural Experiment Station Bulletin # 630. November, 1987.

MacConnell, William P. Remote Sensing Project. Department of Forestry and Wildlife Management. U of Mass., Amherst. 1988.

MAHB. Massachusetts Association of Health Boards, Inc. Letter to S. Russel Sylva, Commissioner, MA. DEQE. August 26, 1987.

Mailo, John R. and Paul Tschetter. "Relating Population Growth to Shellfish Bed Closures: A Case Study from North Carolina." Journal of Coastal Zone Management. vol. 9, no. 1. 1981.

MAPC. Metropolitan Area Planning Council. <u>Hopkington Build-Out Analysis: Impacts of Privately Owned Sewerage Treatment Facilities</u>. Boston, Massachusetts. June, 1988a.

MAPC. Metropolitan Area Planning Council. <u>Population Forecasts for Cities and Towns in Metropolitan Boston</u>. Boston, Massachusetts. February, 1988b.

MAPC. Metropolitan Area Planning Council. Data for Land-Use Changes 1971-1985. December, 1988c.

MAPC. Metropolitan Ara Planning Council. Base Map of Council Region. 1992.

Massachusetts House Report # 6611. "Interim Report of the Special Commission Relative to Management, Operation, and Accessibility of Public Beaches Along the Sea Coast and Other Related Matters." August 21, 1975.

Massachusetts House Bill # 481. "An Act Providing Public On -Foot Free Right of Passage." 1974.

Massachusetts Land Court No. 123432. <u>David B. Smith et. al. V. Planning Board and Board of Health of the City of Gloucester</u>. 1988.

Massachusetts Laws and Liberities. 1648 edition, reprint ed. Cambridge: Harvard University Press. p. 35. 1929

Massachusetts Legislature. House Bill # 6122. "An Act Providing for Improved Wastewater Management in the Commonwealth." 1987a.

Massachusetts Legislature. House Bill # 5177. "An Act Providing for an Environmental Enhancement and Protection Program for the Commwealth." 1987b

Massachusetts Legislature. House Bill # 6122. "'An Act Providing for Improved Wastewater Management in the Commonwealth." Final Version Passed as MGL C. 564. 1987c.

Massachusetts Legislature. House Bill # 4262. Senate Bill No. 955. " An Act Relative to the Application and Regulation of Small Sewage Treatment Plant Technology. January, 1988a.

Massachusetts Legislature. Legislative Testimony. "Acts Related to the Application and Regulation of Small Privately Owned Wastewater Treatment Facilities". Homebuilders of Massachusetts.March 9, 1988b.

Massachusetts State Environmental Code, 310 CMR 15.00, Title V. Minimum Requirements for the Subsurface Disposal of Sanitary Sewage Plus Additions to Title.

Mather, D. Land Use. Longman, London and New York. 1986.

Massachusetts Audubon Society. "Losing Ground: The Case for Land Conservation in Massachusetts." Executive Summary. October, 1988.

MCZM. Massachusetts Coastal Zone Management. "The Way to the Sea, Methods for Massachusetts Communities to Provide Public Access." Boston, Massachusetts. 1985.

MCZM. Massachusetts Coastal Zone Management. Base Map of Coastal Region. 1992.

MDEM. Massachusetts Department of Environmental Management. "Action Plan for Coastal Acquisition and Protection." 1980.

MDEM. Massachusetts Department of Environmental Management. Division of Planning and Development, Coastal Acquisition Strategy. 1987.

MDEM. Massachusetts Department of Environmental Management. Unpublished Paper. 1988.

MDEQE. Massachusetts Department of Environmental Quality Engineering. File #28-300. Letter to the Concerned Citizens of Gloucester. Subject: Superceding Order of Conditions Pertaining to the Castle View Estates Subdivision. October 23, 1987.

MDEQE. Massachusetts Department of Environmental Quality Engineering. Legislative Memorandum. An Act Relative to the Application and Regualation of Small Sewage Treatment Plant Technology. May 10, 1988a.

MDEQE. Massachusetts Department of Environmental Quality Engineering. Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal. Second Draft. January, 1988c.

MDEQE. Massachusetts Department of Environmental Quality Engineering. Letter to James S. Hoyte, Secretary, MA. Executive Office of Environmental Affairs. Subject: Requesting Fail-Safe Review of Castle View Estates. January 4, 1988c.

MDEQE. Massachusetts Department of Environmental Quality Engineering. Groundwater Dishcharge Permits. May 4, 1990.

MDEQE. Massachusetts Department of Environmental Quality Engineering. Rules and Regulations Pertaining to the Subsurface Disposal of Wastewater. State Environmental Code, 310 CMR 15.02 (Title V).

MEOEA. Massachusetts Executive Office of Environmental Affairs. "High Technology in Massachusetts - Its Role and Its Concerns. Commonwealth of Massachusetts. 1985.

MEOEA. Massachusetts Executive Office of Environmental Affairs. "Governor Signs Record Open Space Package." Environmental Outlook. p. 2. January, 1987a.

MEOEA. Massachusetts Executive Office of Environmental Affairs. Letter to EOEA from Metrowest. Subject: POWTFs Impact on Local Open Space Plans. July 14, 1987b.

MEOEA. Massachusetts Executive Office of Environmental Affairs. Permit Decision: Willis Hills Trust Groundwater Discharge Permit Application. no. 0-343. April 19, 1988.

MEOEA. Massachusetts Executive Office of Environmental Affairs. "Generic Environmental Impact Report on Privately-Owned Sewage Treatment Facilities. Prepared by ICF Inc., Boston, Massachusetts. 1990.

MGL C. 21. Massachusetts General Laws, Chapter 21-A, Sec. 13, 310 CMR 15.00. 1978.

MGL C. 40. Massachusetts General Laws, Chapter 40A, The Zoning Act.

MGL C. 41. Massachusetts General Laws, Chapter 41. S. 81Q. 1953.

MGL C. 61. Massachusetts General Laws, Chapter 61, 61A, 61B.

MGL C. 91. Massachusetts General Laws, Chapter 91. Wetlands Waterways Lisencing. 1984.

MGL C. 564. Massachusetts General Laws. Chapter 564. An Act for Providing Enhancement and Protection for the Commonwealth. November 12, 1987.

McGregor, Shea and Doliner. "Comments on the DEIR for Willis Hills Subdivision." Sudbury, MA. Letter to James Hoyte, MEOEA No. 6691. November 25, 1987.

McHarg, Ian. As Quoted. The Express. Easton, Pa. p. 1 February 1, 1978.

McCarthy, James. "Nature Conservation in the United States and Canada: A View from Scotland." NEXUS, Occasional Paper, no. 5. 1989.

McGilvary, Laura, J. "Environmentally Sensitive Coastal Areas." Masters Thesis, University of Rhode Island, 1983.

Melious, Jean O. "The Environmental Quality Acts Substantial Impact on Zoning" Land Use Law and Zoning Digest. no. 39-6. pp 3-6. 1987.

Merriam, Sharan B. Case Study Research in Education. Jossey -Bass Publishers, 1988.

Municipal Impact. Newsletter of Massachusetts Executive Office of Communities and Development. Sept. 1988.

Nakashima, Steve. Board of Health Agent, Gloucester Massachusetts. Personal Interview. January, 1988.

National Resource Defence Council Inc. NRDC Newletter. vol. 6, Issue 1. p. 10. 1977.

Nolan V. California. S.C. No. 86-133. June 26, 1987.

Opinion of the Justices. 365 Mass. 681, 687, 313. 1974.

Pepper, James E. and Robert E. Jorgensen. Influences on Wastewater Management on Land Use: Tahoe Basin 1950 - 1972. EPA-600/5-74-019. October, 1974.

Platt, Rutherford H. The Open Space Decision Process. The University of Chicago, Department of Geography. Research Paper No. 142. 1972.

Quateman, Richard. "Privately-Owned Small "Package" Treatment Plants Threaten New England Environment." New England Environmental News. Fall, 1987.

Quintel, Carlos. The New England Environmental Conference. Subject: Technical Aspcets of POWTFs. Medford, Mass. March 27, 1988.

Ranalli, Ralph. "Developers Resubmit Proposal." Gloucester Daily Times. p.1, c.2. February 11, 1988a.

Ranalli, Ralph. Ruling Stalls Castle View Developer." Gloucester Daily Times. p.1, c.2. February 27, 1988b.

Resource Education Institute, Inc. Seminar Proceeding. "Small Scale Treatment Plants and Other Disposal Systems." Stouffer Bedford Hotel, Bedford, Ma. May 31, 1989.

Ris, Howard. "Integrating Visual Management into the Coastal Zone Planning Process: The Massachusetts Experience." Coastal Zone Management Journal. vol. 9, No. 3/4. 1982.

Rosner, Judy B. "Intergovernmental Tension in Coastal Zone Management, Some Observationsz." Coastal Zone Managemtent Journal. vol. 7, no.1. 1980.

Rupe, Steven. Water Quality Planner, MDEQE. Personal Interview. Februarty, 1988.

Schueler, Thomas R. Controlling Urban Runoff. Department of Environmental Programs, Metropolitan Washington Council of Governments. 1987.

Sheerwood, Reed C., E. Jones Middlebrooks, and Ronald W. Crites. Natural Systems for Waste Management and Treatment. McGraw-Hill Book Co. 1988.

Shope, Judy. Legislative Director, Environmental Lobby of Massachusetts. Presentation before the Joint Committee on Natural Resorces and Agriculture. August 10, 1988.

Smardon, Richard C and J.P. Felleman. "The Quiet Revelution in Visual Resource Management: A View from the Coast." Coastal Zone Management Journal. vol. 9, no. 3/4. 1982.

Smith, L.M. "An Evolving Logic of Participant Observation, Ethanography and Other Case Studies." In L. Shulman (ed>), Review of Research in Education. Chicago: Peacock. 1978.

Steele, D.P., G.W. Peterson and D.D. Friton. "Soil Potential Ratings for On-Site Wastewater Disposal" Journal of Environmental Quality. vol. 15, no 1. 1986.

Storer V. Freeman. 6 Mass. (6 Tyang) 435, 438. 1910.

Tabors, Richard D., Michael H. Shapiro, and Peter P. Rogers. Land Use and the Pipe: Planning for Sewage. Lexington Books, Lexington, MA. 1976.

Ulrich, R. "Some Psycholphysiological Effects of Nature vs. Urban Scenes." Environment and Behavior. vol. 13. 1981.

United States Congress. Coastal Zone Management Act. P.L. 92 -583,. 1972.

United States Congress. National Environmental Policy Act, s. 4321.

United States Congress. Water Pollution Control Act, s. 466.

United States Congress. Clean Water Act. 1972.

United States Congress. The Endangerd Species Act. 1973.

USDA. United States Department of Agriculture, Soil Survey of Essex County, Massachusetts, Southern Part. Soil Conservation Service. May, 1984.

USDUH. United States Department of Housing and Urban Development. 1985.

USEPA. United States Environmental Protection Agency. The Quality of Life Concept: A Potential Tool for Decision Makers. 1973.

USEPA. United States Environmental Protection Agency. The Costs of Sprawl. Real Estate Research Corporation, Council on Environmental Quality, Department of Housing and Urban Development. p. 7. 1974.

USEPA. United States Environmental Protection Agency. Alternatives for Small Wastewater Treatment Systems. EPA-625/4-77-011. 1977.

USEPA. United States Environmental Protection Agency. Onsite Wastewater Disposal Alternatives: A Methodology for Evaluation. A Case History in 208 Water Quality Management Planning. 1978.

USEPA. United States Environmental Protection Agency. The Use of Existing Modified Land Ude Instruments to Achieve Environmental Quality. EPA Contract 600/5-79-006. March 1979.

USEPA. United States Environmental Protection Agency. Design Manual, Onsite Wastewater Treatment and Disposal Systems. October, 1980.

USSCS. United States Soil Conservation Service. Soil Survey of Essex County, Southern Part. 1984

Veneman, P.L.M. Function and Operation of the Conventional Septic System: On-Site Sewage Disposal. Society of Soil Scientists of Southern New England. 1986.

Willis, K.G. and M.C. Whitby. "The Value of Green Belt Land." Journal of Rural Studies. vol. 1, no. 2. pp. 147- 162. 1985.

Wohlwill, J.F. "The Visual Impact of Development in Coastal Zone Areas." Coastal Zone Management Journal. vol. 9, no. 3/4. 1982.

Wolfson, Martin M. "Rural Wastewater Planning." Journal of the Water Pollution Control Federation. vol. 55, no 8, 1983.

Yaro, Robert. "Wetlands Vanishing in Vital Pieces." As cited. Boston Globe. p. 26. August 13, 1989.

Young, Charlotte Holt. "Small Privately Owned Wastewater Treatment Plants and their Potential Use in Massachusetts Single Family Home Developments. Masters Thesis. Urban and Civil Engineering. Tufts University, Medford, Massachusetts. 1989.

Ziegler, Edward H. "Restrictive Zoning and the Courts." Urban Land. September, 1986.

Zwicky, Steven and John Clark. "Environmental Protection in Coastal Land-Use Legislation" Coastal Zone Management Journal. vol. 1, no. 1. 1973.